Fluid, electrolyte and acide-base problems in surgery

L.Dadak
Dept. of Anesthesia and Intensive Care
St. Ann's University Hospital

Laboratory

- Never completely trust the laboratory
  - errors with blood sample
- Will result change my decision?

Never completely trust the laboratory

Quick	<0.10		(0.70 - 1.34)	<-( )	repeated
aPTT	>150	s	(20.0 - 40.0)	<=( )	repeated
Fibrinogen	4.50	g/l	(1.80 - 4.00)	( )->	
Antitrombin III	32	%	(80 - 120)	<-( )	
- - - - - - - - - - - - same patient, 30 min later - - - - - - - - - - - - - -					
Quick	0.55		(0.70 - 1.34)	<-( )	
aPTT	44.7	s	(20.0 - 40.0)	( )->	
Aptt ratio	1.49				
Fibrinogen	5.40	g/l	(1.80 - 4.00)	( )->	
INR	1.59		(0.85 - 1.38)	( )->	
Antitrombin III	61	%	(80 - 120)	<-( )	

Blood for analysis

- arterial
- capillar
- venous
  - periferal
  - central
  - mixed venous (v.cava, a.pulmonalis)

Osmolarity, osmolality

- Each particle present in the water binds number molecules of water.

Serum osmolarity is measured directly by determining the **freezing** point of serum.

normal 275 .. 295 mOsm/l

Calculated osmolarity = 2 * Na + Glc + Urea [mOsm/l]

2* 140 + 5 + 3

Gap > 10 mOsm/l ... another solute (lactate, ethanol)

Gap > 50 mOsm/l ... often fatal

Osmolality [mmol/kg of water]

Electroneutrality

- sum of cations is equal to sum of anions

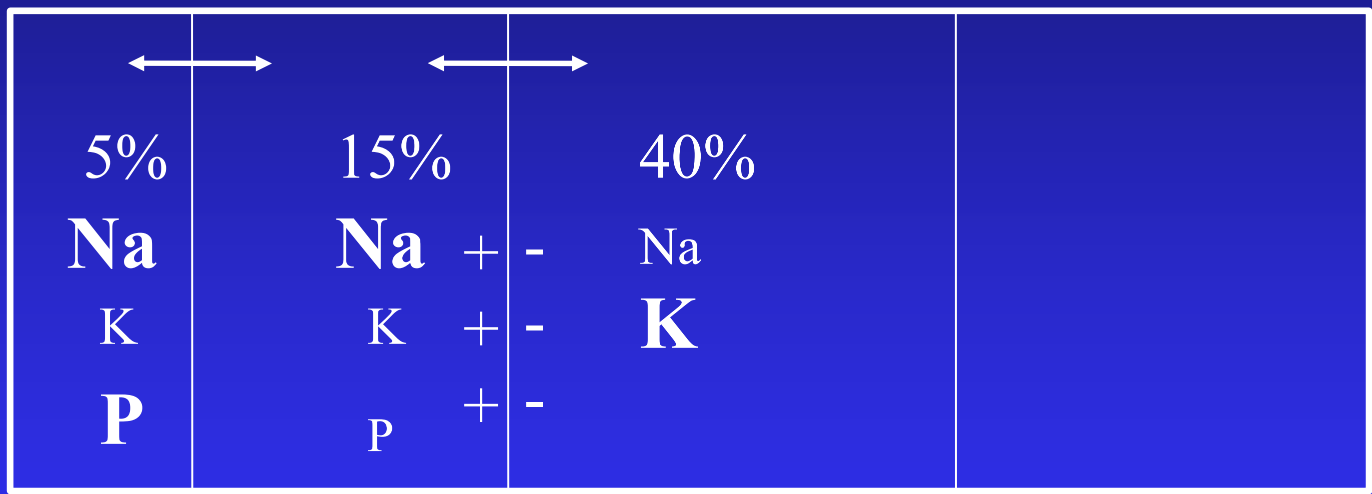
- Na^+, K^+, Mg^{++}, Ca^{++} ...
- Cl^-, HCO_3^-, PO_4^{--}, proteins-

Water

- 55% - 60%, new born 80% of body weight
- Compartment = place of water + ionts

Water - compartments:

ECF = IVF + ISF ICF



Intracellular fluid

- 40% body weight
- more proteins, K^+

Extracellular fluid

- 20% body weight
- interstitial fluid (lymph)
- plasma
- bone
- connective tissue
- transcellular fluid

Homeostasis

- **tendency to keep stable**

- **isovolemia**
- **H+ = pH, pCO_2,**
- **Glc, ions**

- **isohydria, isoionia, isoosmia**

Priorities

1. fluid volume and perfusion deficits
2. correction of pH
3. K, Ca, Mg
4. Na, Cl

Hypovolemia

- deficit of water
- estimated from
  - weight loss
  - thirst
  - physical signs (soft eyes, tachycardia, hypotension, oliguria, organ dysfunction – brain)
- hypo, iso, hypertonic

- Treatment: add water (crystaloid, coloid)

Basic Needs (Adult)

- Basic need 2 ml/kg/h
- Current losses
  - 1°C fever = 500ml/d
  - sweating
  - diarrhea ... water with ions [mmol/l]

	Sodium	Potassium	Chloride	Bicarbonate
Saliva	10–60	10–20	15–40	30–15
Stomach	40–100	5–15	15–20	—
Bile	130–140	4–6	95–105	30–40
Pancreas	130–140	4–6	40–60	80–100
Small intestine	130–140	4–6	40–60	80–100
Colon	80–140	25–45	80–100	30–50
Sweat	40–50	5–10	45–60	—

Hypervolemia

- hypotonic – excess of water (no ions e.g. 5% Glc)
- isotonic – anuria + intake crystaloids
- hypertonic – intake of concentrated solutions, loss of hypoosmolar fluid. / rare/

Ions in the body

- Sodium Na^{+}
- Potassium K^{+}
- Calcium Ca^{++}
- Magnesium Mg^{++}
- Phosphorus PO_4^{-}
- Chloride Cl^{-}

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- Glucose Glc

Sodium Na+

- extracellular fluid 140 mmol/l
- intracellular fluid 10 mmol/l

- Hyponatremia
- Hypernatremia

Hyponatremia Na+ in serum < 120 mmol/l

- usually due to hemodilution by too much water
- sodium loss
  - vomiting
  - diarrhea
  - sweating,
  - renal / CNS disorders, diuretics
  - third space sequestration (burns, pancreatitis, peritonitis)
- factitous (hyperglycemia, hyperlipidemia, manitol) - osmolality normal / increased

Hyponatremia - symptoms

- Fatique
- Apathy, coma, **change in mental status**
- Headache
- Muscle **cramps**, weakness
- Anorexia, nausea, vomiting,

- Mild to moderate hyponatremia is usually asymptomatic.

Treatment of hyponatremia

- stable pat. - water restriction
- severe, acute, symptomatic pat. - 3% NaCl i.v.

Hypernatremia

- inadequate water intake
- excessive loss of water
  - diarrhea
  - vomiting
  - hyperpyrexia
  - excessive sweating
  - diabetes insipidus (ADH) = loss of hypotonic urine
- increased intake of salt
- coma, no responce to thirst

Therapy: Glc 5% i.v.

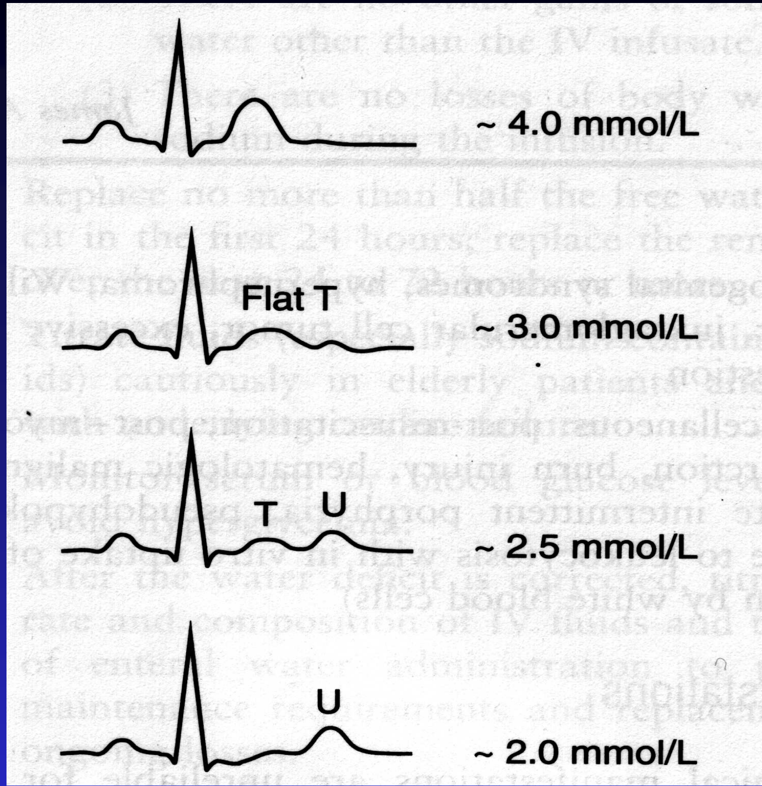
Potassium K+

- Major intracellular cation
- serum (2% of total) 3.8 .. 5.6 mmol/l
- electric potential on membrane (Na+/K+ ATPasa)
- arytmias

- extremly responsive to changes of pH!!

Acidosis in cell (H+) banish K+ out of cell.

Hypokalemia K < 4 mmol/l

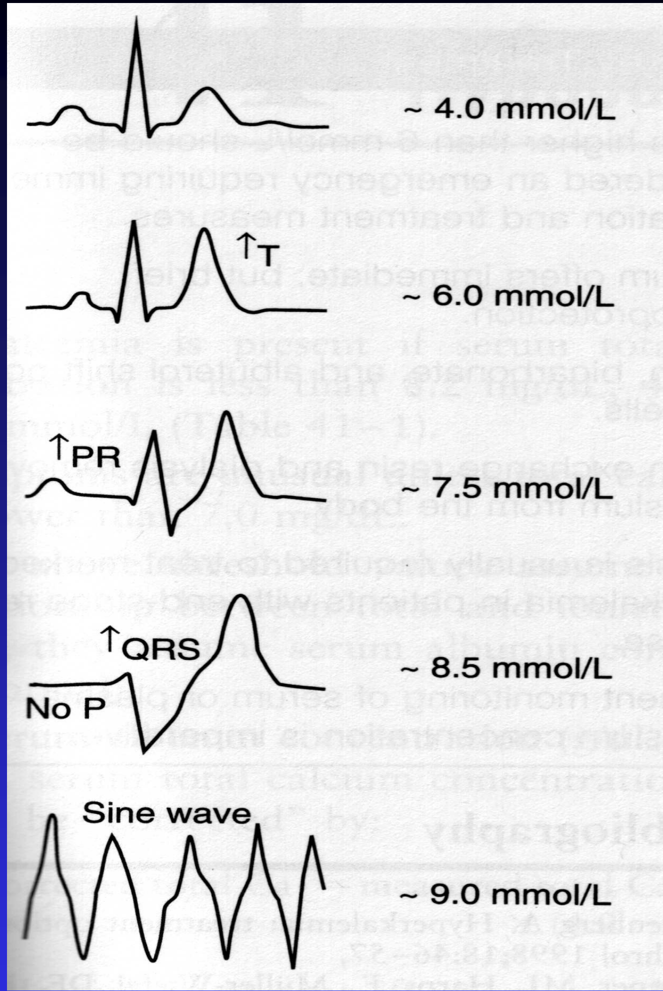


- losses in urine
- diurettics, diarrhea, vomiting
- reduced intake
- Alcalosis
- CAVE severe muscle weakness, asystolia

Treatment:

- KCl p.os; max KCl 40 mmol/h i.v.
- ECG monitoring !!!!

Hyperkalemia



  - hemolysis
  - muscle damage
  - anuria, renal failure
  - Acidosis
- CAVE intracardiac block (diastolic arest) or fibrilation
  - muscle weakness – ventilatory failure

therapy:

  - stop intake
  - Glc + HMR i.v., loop diuretic (furosemide)
  - Calcium i.v., bicarbonate i.v
  - resonium p.os
  - dialysis

Calcium Ca++

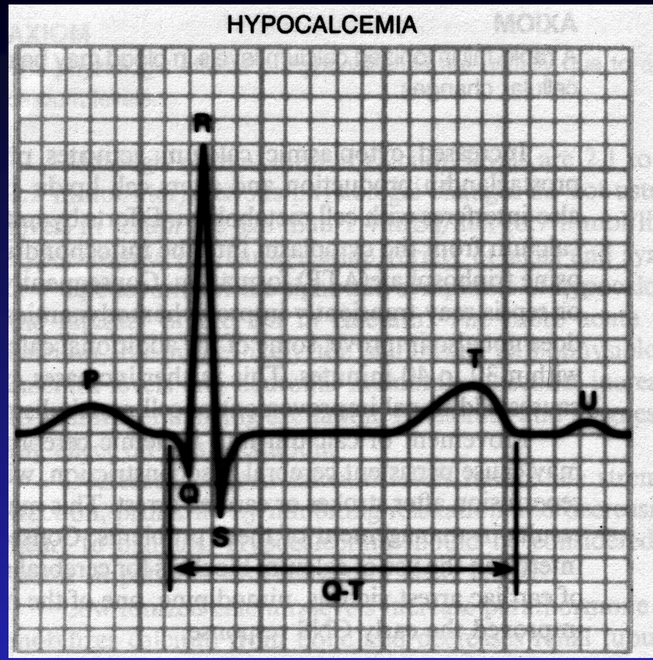
- most abundant mineral in the body 2kg
- Parathormone PTH
  - stimulate osteoklast
  - stimulate intestine
  - resorption in kidney
- Calcitonin
  - inhibites osteoklast
- Vitamine D
  - potens saving Ca++

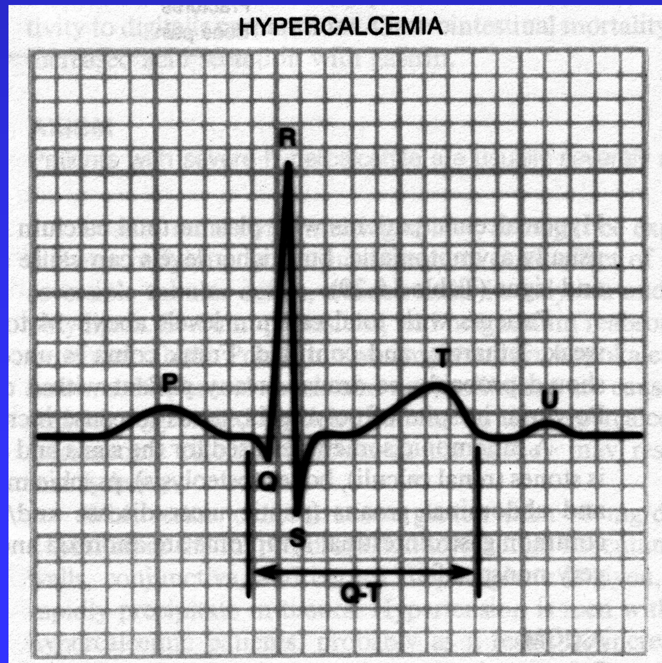
Ionised Ca = 1.1 mmol/l // efect of all Calcium

bound by proteins =ineffective to receptors

Calcium Ca++

- Hypocalcemia
  - Respiratory Alcalosis, hypoPTH,
  - shock, sepsis, pancreatitis
  - together hypomagnesemia
- Hypercalcemia
  - muscle damage
  - malignancy





Chloride Cl-

- Major anion in Extracellular fluid
- see ABR

Glucose

- hyperglycemia
- hypoglycemia / insulin overdose/

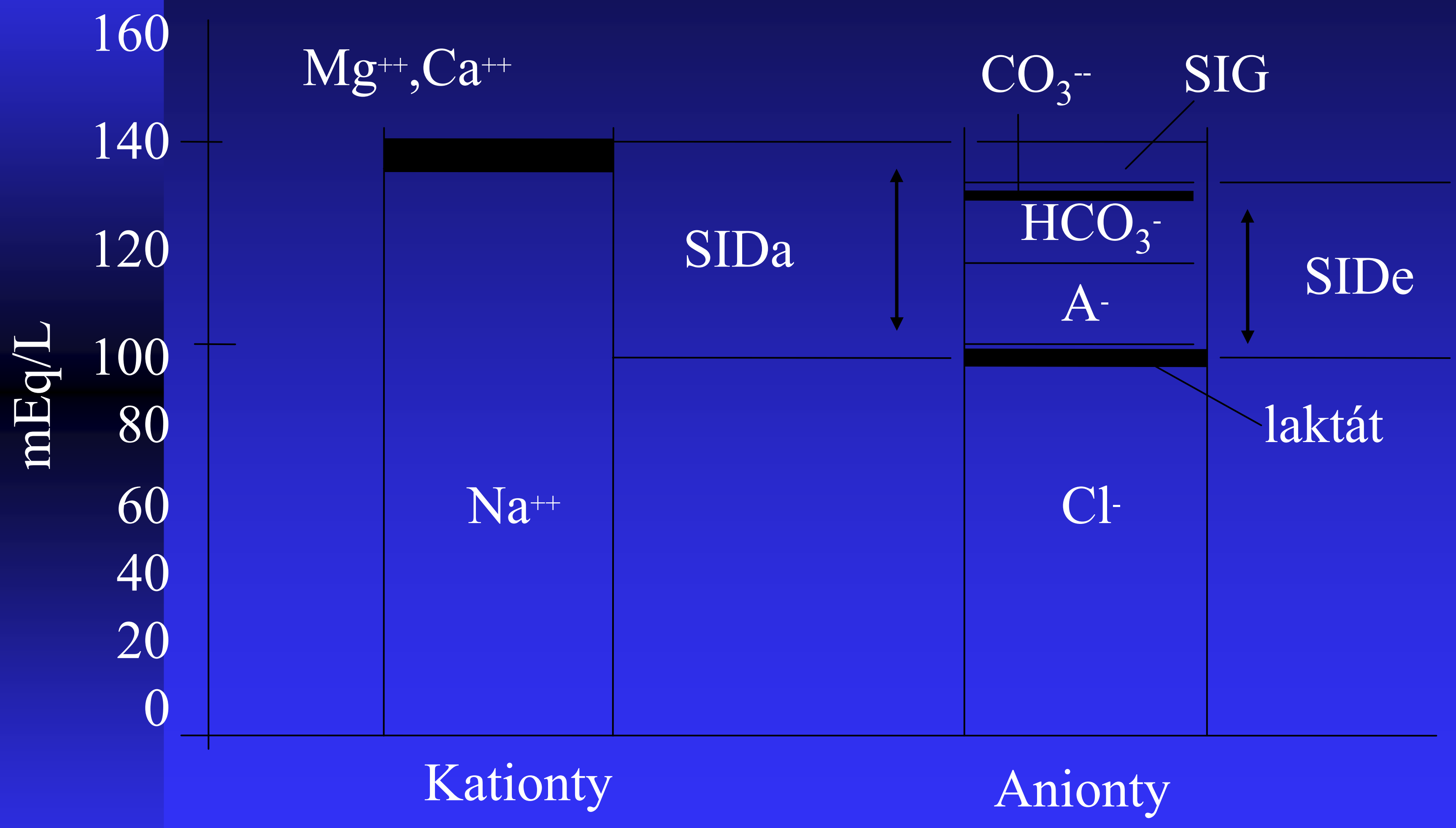
- next week

Acide-base

arterial blood:

pH	7,35-7,45
pCO_2	4,6-6 kPa
pO_2	10-13 kPa
HCO_3^-	22-26mmol/L
BE	-2 .. +2 mmol/L
SpO2	95-98%

Steward's principle



CO2

$$Glc + O_2 \rightarrow CO_2 + H_2O$$

$$CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$$

ΔpH Δ p CO2

0.1 1,6 kPa = 12 mmHg

Genesis of Acid = giver of H^+

- lactate - shock
- strong acids intake (HCl, H_2SO_4)
- acetylsalicilic acid (drug overdose)
- ...

ΔpH Δ p CO_2

0.1 1,6 kPa = 12 mmHg

Basic laws

pH = - log [H+] [H+] ... mol/l

pH = pK + log (H+ acceptor /H+ donor)

- acidosis pH < 7.36
- alcalosis pH > 7.44

Place of error:

- Respiratory (lung) ... pCO2
- Metabolic (kidney) ... BE

BE = number of acid needed to correct sample to 7.4

Not exact true...
... but it helps

ΔpH	BE	Δ p CO_2
0.1	6mmol/l	1,6 kPa = 12 mmHg

Kilopascals for PCO_2.

- Many texts and papers express the PCO_2 in kilopascals (kPa). It is useful to remember that this value is almost the same as the percentage of atmospheric pressure. For example, the normal arterial PCO_2 of 40 mmHg is 5.33 kPa or 5.61 %.
- To convert pressure in mmHg to kPa, it is necessary to divide the value in mmHg by 7.5.

RAc

- **Respiratory Acidosis.** The decision to ventilate a patient to reduce the PCO_2 is a clinical decision and is based on exhaustion, prognosis, prospect of improvement from concurrent therapy, and in part on the PCO_2 level. Once the decision is made, the PCO_2 helps to calculate the appropriate correction. The PCO_2 reflects a balance between the carbon dioxide production and its elimination. Unless the metabolic rate changes, the amount of carbon dioxide to be eliminated remains constant. It directly determines the amount of ventilation required and the level of PCO_2. Where V_T equals tidal volume and f equals respiratory rate:
- PCO_2 x Ventilation = Constant, i.e.,
  $PCO_2 \times V_T \times f = k$

MAc

- **kidney unable to eliminate H+ = anuria**
- **big production of acides.**

- The treatment for a metabolic acidosis is, again, judged largely on clinical grounds. Bicarbonate therapy is justified when metabolic acidosis accompanies difficulty in resuscitating an individual or in maintaining cardiovascular stability.
- A typical dose of bicarbonate might be 1 mEq per kilogram of body weight followed by repeat blood gas analysis.
- Calculation is based on BE and the size of the treatable space (0.3 x weight, e.g., 21 liters):
Dose (mEq) = 0.3 x Wt (kg) x BE (mEq/L).

RAl

- hyperventilation
- lost of ionized Calcium / hypocalcemia / tetania

MAl

- increased loss of NH4 to urine
- saving HCO3- by kidney
- loss of Cl- (vomiting)

- BE > O
- pH > 7.44
- Th: i.v. FR (NaCl)

How to

1. what is wrong
2. what the body do
3. what to do

OR / AAA, 5 000ml lost, haemorh. shock, NA i.v., general anesthesia, VCV

pH akt.	***7.083***		***(7.350 - 7.450)***	***<-( )***
pCO_2	6.36	kPa	(4.80 - 5.90)	( )->
pO_2	30.78	kPa	(10.66 - 13.30)	( )=>
BE	-15.8	mmol/l	(-2.6 - 2.6)	<=( )
BB	32.1	mmol/l	(40.0 - 44.0)	<=( )
HCO_3 akt.	13.9	mmol/l	(22.0 - 26.0)	<=( )
O_2 sat.	99.3		(95.0 - 98.0)	( )=>

OR / AAA, 6 500ml loost, haemorh. shock, NA i.v.

pH akt.	***7.1***	***(7.350 - 7.450)***	***<=( )***
pCO2	5.0 kPa	(4.80 - 5.90)	(*)
BE	-18 mmol/l	(-2.6 - 2.6)	<=( )
lactate	13 mmol/l	(1 – 2.5)	( )= =>

Try it yourself

pH = 7,2

pCO2 = 14 kPa

BE = 20 mmol/l

pH 7,35-7,45

pCO_2 4,6-6 kPa

pO_2 10-13 kPa

HCO_3^- 22-26mmol/L

BE -2 .. +2 mmol/L

SpO2 95-98%

SUMARY

- Biologic system react primary to rate of change and not to absolute concentrations.
- Abnormalities should be treated at proximately the rate at which they developed.
- DO NOT rapid correction of a chronic asymptomatic abnormality.

When order electrolytes exam:

- poor oral intake
- vomiting
- chronic hypertension
- diuretic use
- recent seizure
- muscle weakness
- age over 65
- alcoholism
- history of electrolyte abnormality

When order blood gasses:

- acid-base problems
- artificial ventilation

acute CNS change

immediately look for

- hypoxemia
- hypoglycemia
- hyponatremia
- sepsis

Priorities

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Bleeding – transfusion strategy

Indication:	Transfuse to Maintain:
Transfuse any symptomatic patient (e.g., tachycardia, hypotension, CHF, angina)	Until no longer symptomatic
Asymptomatic, presurgical, stable patient	Hb 7-8 g/dl
Hemodynamically stable postsurgical stable patient	Hb 8 g/dl
Postsurgical patient at risk for ischemic disease (e.g., cardiac, bowel)	Hb 10 g/dl
Hemodynamically stable, nonpregnant, ICU patients >age 16 without ongoing blood loss	Transfuse at 7 g/dl to maintain Hb at 7-9 g/dl

- Estimated blood loss.
- Intraoperative fluids and blood products administered.