لا تنسوا زميلاتكم من دعائكم

SERUM ELECTROLYTE ANIONS

Chloride

- The major extracellular anion
- Function in body:
  - Maintaining osmolality
  - Blood volume and
  - Electric neutrality
- Cl is usually shifted according to Na and bicarbonate
- Excess chloride in the body is excreted in urine and sweat, excessive sweating will induce the release of aldosterone which will conserve Na and Cl

بساعد مع الNa بعملية تنظيم الosmolality

بما انه الNaاله charge+ لازم يكون في charge- وهو الCl

يتبع الNa والbicarbonate عادة يعني اذا صار Na للexcreation رح يروح معه سواء عن طريق الurin or sweating

ولما يصير افراز للaldesteron عشان يعمل retintion للNa رح يعمل برضه للCl والH2O

Chloride

- Chloride maintains electrical neutrality in two ways:
- Na is reabsorbed along with Cl in the proximal tubules. Na reabsorption is limited by the amount of Cl- available بالreabsorption للNa اذا كانت كمية الCl قليلة مارح يصير امتصاص لكل كمية الNa رح يصير امتصاص كمية مكافئة لكمية الCl الموجودة
- Electroneutrality is also maintained by chloride through the chloride shift.
  - Carbon dioxide generated by cellular metabolism within the tissue diffuses out into both the plasma and the red cells
  - In the red cell, CO2, forms carbonic acid (H2CO3), which splits into H+ and HCO3- (bicarbonate).
  - Deoxyhemoglobin buffers H+, whereas the HCO3- diffuses out into the plasma and Cl diffuses into the red cell to maintain the electric balance of the cell.

$$CO_2 + H_2O \xleftrightarrow{CA} H_2CO_3 \xleftrightarrow{CA} H^+ + HCO_3^-$$

CO_2 : بتحمل على الRBCوببلش يتحرك بالدم ليوصل الlung ويطلع برا ، جزء من الCo2 رح يتحول ل carbonic acin عن طريق انزيم اسمه carbonic anhydrase

H_2CO_3 : ح يصير اله disscoiation ل H+ و HCO3-

الdeoxyhemo globin لازم يتحول ل oxyhemoglobin عن طريق انه يشيل الHCO3- ويحط بدالها O2 الH+ رح تنسحب للRBCعشان تعادل الHCO3
وهيك الHCO3- رح تروح للبلازما وبما انها طلعت من الRBC شحنه سالبة لازم اشي يروح بدالها وهو الCl

اذا انخفض تركيز الHCO3- تركيز الCl رح يرتفع

Chloride applications

- Chloride disorders are often the result of the same causes that disturb Na levels because chloride passively follows Na مش حكينا انه الCl يتبع الNa، فاي اشي بخربط الNa رح يخربط الCl
- There are a few exceptions. في حالات ثانية
  - Hyperchloremia may also occur when there is an excess loss of bicarbonate as a result of GI losses, RTA or metabolic acidosis اذاالواحد كان بفقد الHCO3-لعدة اسباب زي 1,2,3ال Cl رح يرتفع لحتى يعدل الوضع
  - Hypochloremia may occur with excessive loss of chloride from prolonged vomiting, diabetic ketoacidosis, aldosterone deficiency or salt-losing renal diseases. ممكن يقل تركيزه لانع يصير اله loss بسبب 1,2,3,4
  - A low serum level of chloride may be encountered in conditions associated with high serum bicarbonate concentrations such as compensated respiratory acidosis or metabolic alkalosis. لما يرتفع الHCO3- اذا ارتفع الCl رح ينخفض

لانه رح يعمل مشكله مع Na retention وهيك رح يقل الCl retention

Determination of the chloride

- Specimen: serum or plasma, whole blood samples, urine (24-hr) or sweat may be used
- Lithium heparin is the anticoagulant of choice. → لما بدي اخذ plasma sample
- Hemolysis does not cause significant change in serum or plasma values as a result of decreased levels of intracellular chloride (marked hemolysis, decrease due to dilutional effect).

كـ ١:١٠ كان خفيف ما رح يكون التأثير كبير و بس اذا كان كثير رح يعمل Cl ↓ وهيك dilution effect

- Methods: there are several methodologies includes:
  - ISE (most commonly used where an ion-exchange membrane is used to selectively bind Cl ions)
  - Amperometric coulometric titration
  - Mercurimetric titration
  - Colorimetry

باختصار: Cl⁻ لقياس Ion-Selective Electrode (ISE)

• جهاز يقيس تركيز أيون محدد (مثل Cl^-) في الدم أو البول.

] موجودين بالسلايد العملي

Reference range

TABLE 15-10 REFERENCE RANGES FOR CHLORIDE

Plasma, serum	98–107 mmol/L
Urine (24-h)	110–250 mmol/day, varies with diet

حسب diet

Amperoetric coulmetric Titration

باختصار Amperometric Coulometric Titration:

- طريقة **معايرة كهربائية** تعتمد على **التيار الكهربائي** لتفاعل المادة في العينة.
- يقاس **التيار الكهربائي (Amperometry)** لمتابعة التفاعل.
- تُحسب **كمية المادة** من خلال **الشحنة الكهربية المارة (Coulombs)** باستخدام قانون فاراداي.
- مزاياها: دقيقة جدًا ولا تحتاج مؤشرات كيميائية.

Colorimetry

باختصار Colorimetric method للكلوريد (Cl^-):

- تعتمد على **تفاعل Cl^- مع مؤشر كيميائي لتكوين لون**.
- شدة اللون **تتناسب مع تركيز Cl^-**.
- يُقاس اللون باستخدام **Spectrophotometer** لتحديد التركيز بدقة.

Bicarbonate

- Is the second most abundant anion in the ECF
- The total CO2 comprises the bicarbonate (90%), carbonic acid and dissolved CO2 so total CO2 measurement is indicative of HCO3- measurement نقدر نقيسه كله على شكل CO2 او كله على شكل HCO3 رح نحكي عنها كمان شوي
- Bicarbonate is the major buffering system in the blood where carbonic anhydrase in RBCs converts CO2 and H2O to carbonic acid

حكيت عنه قبل شوي
الاشي الي ما حكيته انه بقدريرجع الH+ وال HCO3- للcarbonic acif
(H2CO3)

$$CO_2 + H_2O \xleftrightarrow{CA} H_2CO_3 \xleftrightarrow{CA} H^+ + HCO_3^-$$

- Bicarbonate diffuses out of the cells in exchange for chloride to maintain ionic charge neutrality within the cell

Bicarbonate regulation

- Most of the filtered bicarbonate ion is reabsorbed in the kidneys (85% in proximal tubules and 15% in the distal) in the form of CO2 (due to low permeability of tubules to bicarbonate)
- Normally nearly all the bicarbonate ions are reabsorbed from the tubules, with little lost in the urine ال excreation الها قليل
- When bicarbonate ions are filtered in excess of hydrogen ions available, almost all excess HCO3- flows into the urine. اذا صار excess من ال HCO3- مقارنه بتركيز الH+ رح يصير ecxreation لل HCO3-(هذا بحاله الalkalosis)
- In alkalosis, with relative increase in bicarbonate ion compared to CO2, the kidneys increase excretion of HCO3- into the urine, carrying along a cation such as sodium. This loss of HC3O- from the body helps correct pH بال acidosis رح يصير excess من الH+ وهيك بصير completly reabsorption for HCO3- وال H+ هي للي رح يصير الها escreatin
- In acidosis, the excretion of H into the urine is increased and HCO3- reabsorption is complete

Clinical applications

بصير لما يكون في metabolic acidosis بصير الواحد يطلع كميات كبيرة من ال(CO2(acidic وعشان اخفف من الacidity من الدم بصير يتنفس بسرعة hyperventilation

- Acid-base imbalances cause changes in bicarbonate and CO2 levels. A decreased bicarbonate/ CO2 occurs in metabolic acidosis leads to exhalation of CO2 by the lungs (hyperventilation), which lowers pCO2.

اذا صار alkalosis الجسم بحاول يقلل التنفس ويحاول يحبس الCO2ويقلل الph العالية للوضع الطبيعي

- Elevated total CO2 concentrations occur in metabolic alkalosis as bicarbonate is retained, often with increased pCO2, as a result of compensation by hypoventilation.
- Typical causes of metabolic alkalosis include:
  - Severe vomiting

بخسر H+ كثير نتيجه الvomiting بس الHCO3 ما بصير عليه اشي

  - Hypokalemia

لما يقل الK بالدم الخلايا رح تطلع الK لبرة وتدخل بداله H+ وهيك ال H+ رح تقل بالدم ويصير alkalosis

  - Excessive alkali intake

اذا كان بياخذ كميات كبيرة من ادوية فيها HCO3- او الantacid رح تعمل alkalosis

Method

- Specimen: venous serum or plasma.
- Serum or lithium heparin plasma is suitable for analysis.
- The sample is capped until the serum or plasma is separated and the sample is analyzed immediately
- If the sample is left uncapped before analysis, CO2 escapes. Levels can decrease by 6 mmol/L per hour

اذا فتحنا الtube الي في الsample ممكن تطلع الCo2 من الsample وتروح للجو عشان هيك لازم نغطيها
ولا رح يصير فقدان لل conc of HCO3 بمقدار 6mmol/L ورح بعطيني انه في نقص وهو مافي

- Two common methods are ISE and an enzymatic method.
  - ISE for measuring total CO2, uses an acidic reagent to convert all the forms CO2 to CO2 gas and measured by a pCO2 electrode

ال ICEبقيس كل الCo2 الموجود بالدم فلازم اعمل بالاول acidificationt عشان احول
كل الHCO3 للH2CO3 وبعدين للCo2 وبعدها بقيس الpCO2

  - The enzyme method alkalinizes the sample to convert all forms of CO2 to HCO3-.

الطريقة اثانية تعمل alkalinization لكل الCO2الموجوده وبتحوله لHCO3-

اذا حولته كله لHCO3 شو رح تكون الخطوة الثانية

Method

جايه من العينة

- HCO3 is used to carboxylate phosphoenolpyruvate (PEP) of phosphoenolpyruvate (PEP) carboxylase, which catalyzes the formation of oxaloacetate.

$$\text{Phosphoenolpyruvate} + HCO_3^- \xrightarrow{\text{PEP carboxylate}} \text{Oxaloacetate} + H_2PO_4^- \qquad \text{(Eq. 15-4)}$$

- This is coupled to the following reaction, in which NADH is consumed as a result of the action of malate dehydrogenase (MDH)

$$\text{Oxaloacetate} + NADH + H^+ \xrightarrow{\text{MDH}} \text{Malate} + NAD^+ \qquad \text{(Eq. 15-5)}$$

- The rate of change in the absorbance of NADH is proportional to the concentration of HCO3-

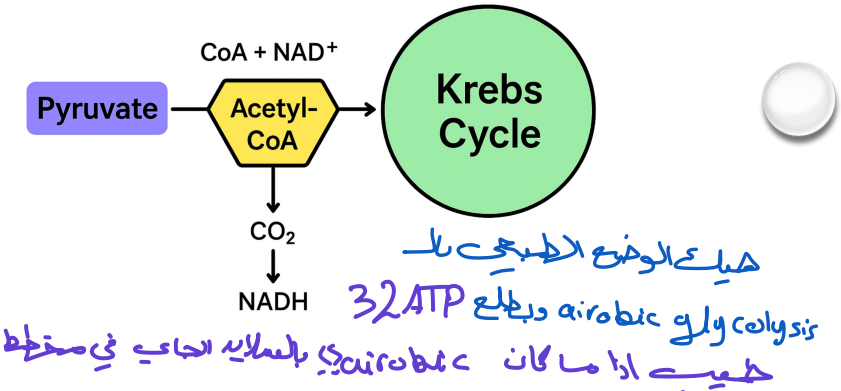
Reference ranges

- Carbon dioxide, venous 23-29 mmol/L (plasma, serum).

جاك رح يكون اقل arterial

Lactate

regulation اشي ما بصير اله

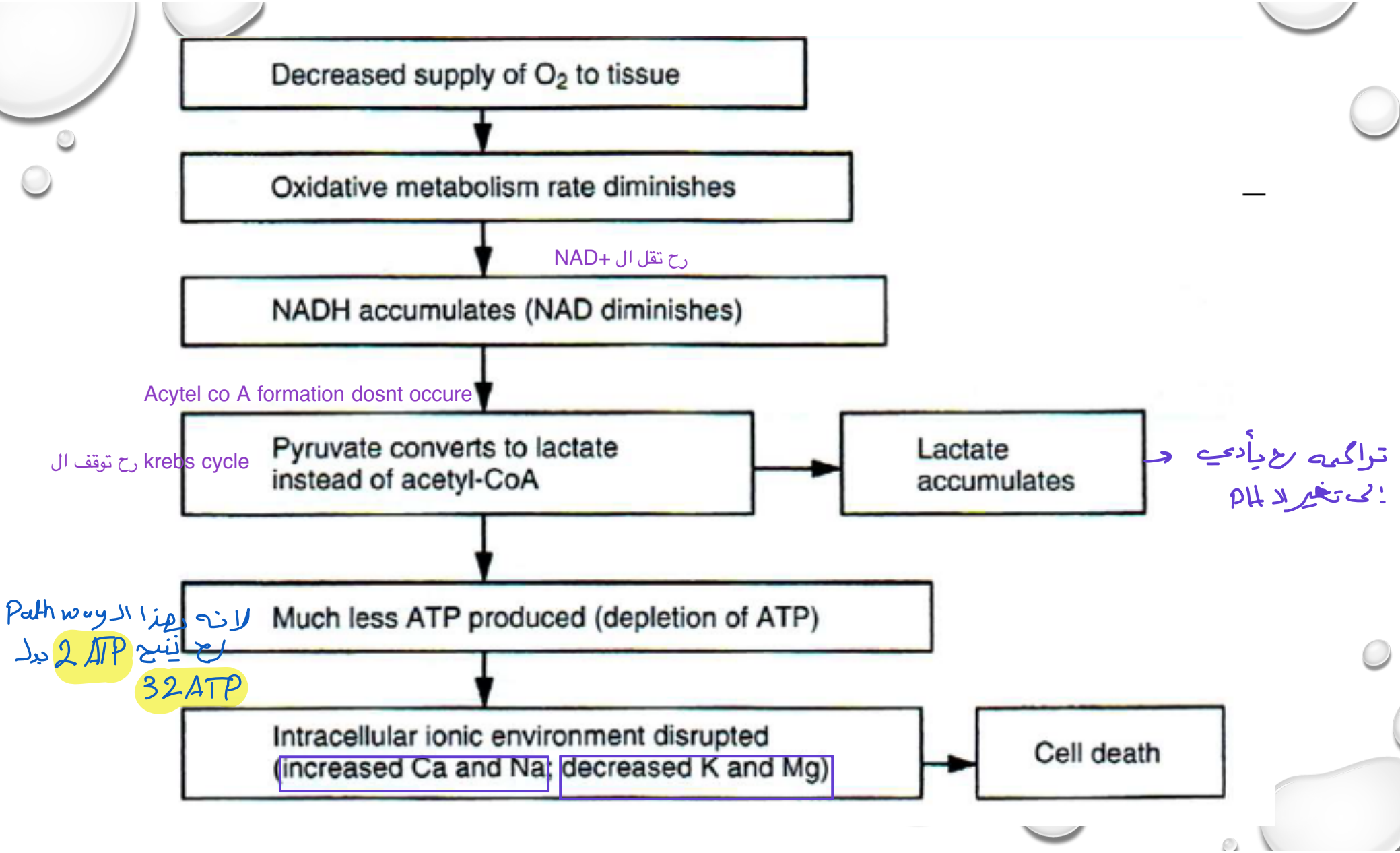


- Lactate is a by-product of an emergency mechanism that produces a small amount of ATP (2 moles)

يعني صار عنده hypoxia ولجأ لل anairobic
ويعني رح يصير يطلع كميات قليلة من الطاقة glycolosis

- Under hypoxic conditions, acetyl CoA formation does not occur and NADH accumulates, favoring the conversion of pyruvate to lactate through anaerobic metabolism.

- The accumulation of excess lactate in blood is an early sensitive and quantitative indicator of the severity of oxygen deprivation (more than pH)


Decreased supply of O_2 to tissue
Oxidative metabolism rate diminishes
رح تقل ال +NAD
NADH accumulates (NAD diminishes)
Acytel co A formation dosnt occure
رح توقف ال krebs cycle
Pyruvate converts to lactate instead of acetyl-CoA
Lactate accumulates
تراكمه رح يأدي
لـ تغيير الـ PH
لانه هيدا الـ Pathway
رح ينتج 2 ATP بدل
32ATP
Much less ATP produced (depletion of ATP)
Intracellular ionic environment disrupted (increased Ca and Na; decreased K and Mg)
Cell death

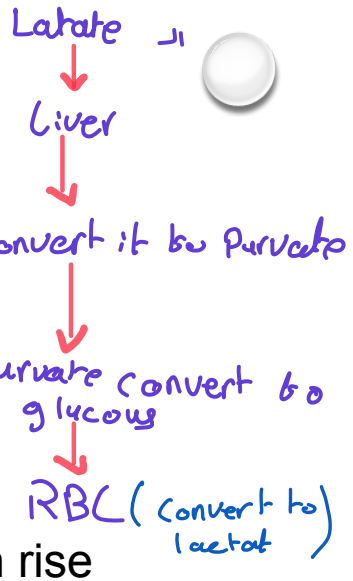
اشي مش طبيعي بالجسم الخلايا الوحيدة الي بتطلعه بشكل Normalخلايا الدم الحمراء لانه ماعندها مايتوكندريا

Regulation

- It is not regulated as with potassium and calcium

- As oxygen delivery decreases below a critical level, blood lactate concentration rise rapidly and indicate tissue hypoxia earlier than pH

- The liver is the major organ for removing lactate by converting lactate back to glucose by a process called gluconeogenesis



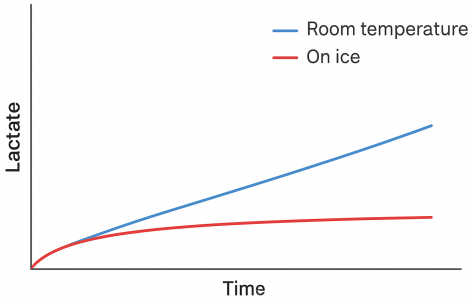
Clinical application

- Measurement of blood lactate are useful for metabolic monitoring in critically ill patients, for indicating the severity of the illness, and patient prognosis

There are two types of lactic acidosis:

- Type A is associated with hypoxic conditions, such as shock, myocardial infarction, severe congestive heart failure, pulmonary edema, or severe blood loss
- Type B is of metabolic origin, such as with diabetes mellitus, severe infection, leukemia, liver or renal disease, and toxins (ethanol, methanol, or salicylate poisoning).

Determination of lactate



صورة توضيحية

الواحد لازم يكون حريص عشان Lactate اي حركه زيادة ممكن تزيد conc والوقت زيادة رح يؤدي لزيادة

- Special care should be practiced when collecting and handling specimens for lactate levels

ممنوعة ربط الإيد عشان نعرف نشوف الـ vein

- A tourniquet should not be used because venous stasis will increase lactate levels

يعني إذا كان الـ vein مبين ايدآ ممكن استخدمها بس بسرعة باخذ العينة

- If a tourniquet is used, blood should be collected immediately and the patient should not exercise the hand before and during collection

يعني انه يفتح ايده حد ويسكرها

عشان 30 min بين serum اللي plasma اخذها رح آخذ العينه اقدر اشتغل فيها وهذا إشي مرفوض ولما اخذها بآ احطها بسرعة او احطها بـ ice

- After sample collection, glucose is converted to lactate by a way of anaerobic glycolysis and should be prevented:

Method

- Current enzymatic methods make lactate determination readily available.
- The most commonly used enzymatic method uses lactate oxidase to produce pyruvate and H2O2.

$$\text{Lactate} + O_2 \xrightarrow{\text{Lactate oxidase}} \text{pyruvate} + H_2O_2$$

- One of two couple reactions may then be used. Peroxidase may be used to produce a colored chromogen from H2O2

$$H_2O_2 + \text{H donor} + \text{chromogen} \xrightarrow{\text{Peroxidase}}$$

$$\text{colored dye} + 2H_2O$$

بتقيسها بجهاز الـ UV

Reference range

ENZYMATIC METHOD, PLASMA	
Venous	0.5–2.2 mmol/L (4.5–19.8 mg/dL)
Arterial	0.5–1.6 mmol/L (4.5–14.4 mg/dL)
CSF	1.1–2.4 mmol/L (10–22 mg/dL)

Anion gap (AG)

الاصل انه في كمان anion وكمان cation

- Routine measurement of electrolytes usually involves only Na+, K+, Cl-, and HCO3-
- These values may be used to approximate the anion gap (AG), which is the difference between unmeasured anions and unmeasured cations.
- There is never a “Gap” between total cationic charges and anionic charges
- AG is useful in indicating an increase in one or more of the unmeasured anions in the serum and also in the form of quality control for the analyzer used to measure these electrolytes.

Anion gap (AG)

anion بتصير لما يرتفع واحد من ال

- There are two commonly used methods for calculating the anion gap

$$AG = Na^+ - (Cl^- + HCO_3^-)$$

- With a reference range of 7-16 mmol/L
- The second method:

$$AG = (Na^+ + K^+) - (Cl^- + HCO_3^-)$$

- It has a reference range of 10-20 mmol/L

الـ Rang الطبيعي

لما يرتفع واحد من الـ electrolyte

الـ lactat زي unmesured

الجسم رح يحاول يعادل هاي

الزيادة عن طريق انه يرفع واحد من

الـ cation زي الـ Na مثلاً

$AG = (Na^+ + K^+) - (Cl^- + HCO_3^-)$

بس الـ Na و K ما بعادلوا الـ Cl و الـ HCO_3

بهاي الحالة لكونو بعادلوا الـ

lactate و هيك رح يصير

الـ unmesured

الـ gap المفروض ما يكون في

gap بس لما واحد من الـ anion

حسبتها هو المرتفع و الـ Na

بحاول يعادله

Anion gap (AG)

- An elevated anion gap may be caused by:
  - Uremia/renal failure, which leads to PO4-3 and SO4-2 retention
  - Ketoacidosis, as seen in cases of starvation or diabetes
  - Methanol, ethanol, ethylene glycol poisoning, or salicylate
  - Lactic acidosis
  - Hypernatremia
  - Instrument error

CASE STUDY 15-2

A 60-year-old man entered the emergency department after 2 days of "not feeling so well." History revealed a myocardial infarction 5 years ago, when he was prescribed digoxin. Two years ago, he was prescribed a diuretic after periodic bouts of edema. An electrocardiogram at time of admission indicated a cardiac arrhythmia. Admitting lab results are shown in Case Study Table 15-2.1.

Questions

1. Because the digoxin level is within the therapeutic range, what may be the cause for the arrhythmia?
2. What is the most likely cause for the hypomagnesemia?
3. What is the most likely cause for the decreased potassium and ionized calcium levels?
4. What type of treatment would be helpful?

CASE STUDY TABLE 15-2.1 LABORATORY RESULTS

VENOUS BLOOD
Digoxin: 1.4 ng/mL, therapeutic 0.5–2.2 (1.8 nmol/L, therapeutic 0.6–2.8)
Na^+: 137 mmol/L
K^+: 2.5 mmol/L
Cl^-: 100 mmol/L
HCO_3^-: 25 mmol/L
Mg^{2+}: 0.4 mmol/L
Ion/free Ca^{2+}: 1.0 mmol/L

Na 135-145
K 3.4-5.0
Cl 98-107
HCO3 23-29
Mg 0.63-1.0
Ca/ionized 1.16-1.32

شرحها موجود في المحول