

Laboratory assessment of acid-base imbalance

Vyšetření krevních plynů a vnitřního prostředí dle Astrupa, nověji **vyšetření acidobazické regulace** poskytuje informacemi o:

- blood pH;
- partial pressure of oxygen (pO_2);
- partial pressure of carbon dioxide (pCO_2);
- percentage of oxygenated blood in arteries (sO_2).

It's also possible to assess individual fractions of hemoglobin (oxyhemoglobin, methemoglobin...) and calculate other values **acid-base balance**. Arterial, arterialized capillary or central venous blood is used for examination. The sample must be taken anaerobically.

Indication

Examination of blood gases and acid-base balance is one of the basic methods for ventilation and respiratory disorders (for example COPD, bronchial asthma, heart defects, severe lung disease, heart disease), in case of disorders of the internal environment (in kidney and liver disease, some poisons, during intensive infusion therapy, in drug-induced disorders of the internal environment) etc.

Preanalytical phase

The best sample is **arterial blood**. It is most often taken from a radial artery into capillary on thin needle or into modified syringe, as anticoagulants we use lithium-heparin. On intensive care units arterial catheter is inserted, which allows repeated blood sampling. In every case it's important to ensure that the sample is without air bubbles.

Other possibility is the collection of '*arterialized capillary blood*', usually from fingers or earlobe. Capillary sample should match the arterial blood the most by structure. Therefore it's important to increase the blood flow in capillaries in locations, where the blood sample is taken from („arterialization") – by warming up, by massaging etc. Capillary blood sample is carried into the heparinized capillary, the sample must be without air bubbles also.

On examination of *venous blood* the sample should be taken from central venous system (z central venous catheter, port). Peripheral venous blood doesn't inform us about the overall metabolic status of the organism enough, especially in patients in difficult state with centralized circulation. Central venous blood is taken into syringe with balanced lithium-heparin, in this case the sample must be anaerobic also. The sample should be processed until 15 minutes from the sample. It is necessary to indicate the type of consumption in the request.

Analytical phase

The material is processed using automatic analyzers. These parameters are measured:

Actual pH

Actual pH is determined electrochemically, usually with a miniaturized glass electrode.

Carbon dioxide partial pressure.

Carbon dioxide partial pressure (pCO_2) is determined electrochemically by a Severinghaus electrode. It is also a glass electrode, but it is coated with a layer of water and separated from the sample by a gas-permeable membrane. CO_2 from the sample diffuses through a semipermeable membrane into distilled water, the pH of the resulting solution depends on pCO_2 .

Oxygen partial pressure

Oxygen partial pressure is measured electrochemically by Clark's oxygen electrode.

Further examination

At the same time, hemoglobin oxygen saturation and hemoglobin concentration are usually measured. Depending on the type of analyzer available, it is possible to determine the concentration of glucose, lactate, sodium, potassium, chlorides, ionized calcium (Ca^{2+}) in the same sample. For neonatological purposes, the determination of fetal hemoglobin and "neonatal" bilirubin can be performed simultaneously.

Calculated parameters

From the measured values of pH and pCO_2 the "current" and "standard bicarbonates", base excess and possibly other parameters are calculated.

Significance and interpretation of acid-base balance parameters

pH

Normal values: **7,36-7,44**

Deviation of blood pH from the norm is referred to as "acidemia" or "alkalemia"..

The resulting pH informs about the severity of the indoor environment disorder and about the degree of compensation or correction of any ABB disorder. In the case of compensated and corrected disorders, it is almost always true that if the primary disorder is acidosis, the actual pH is lower than 7.4, and conversely, if the primary disorder is alkalosis, the actual pH is higher than 7.4.

pCO₂

Normal values: **5,3±0,5 kPa**

Informs about the respiratory component of acid-base balance. Hypocapnia accompanies hyperventilation and respiratory alkalosis, hypercapnia conversely, respiratory insufficiency and respiratory acidosis.

Topical bicarbonates

Normal values: **24±2 mmol/l**

This parameter indicates the current concentration of bicarbonates in the examined blood. Due to the fact that it depends on the metabolic and respiratory component of acid-base balance, its interpretation is complicated.

Standard bicarbonates

Normal values: **24±2 mmol/l**

The calculated parameter expresses what would be the concentration of bicarbonates in the examined blood sample "" after exclusion of the respiratory disorder ", ie after saturation of the blood at pCO₂ = 5.3 kPa. It therefore informs only about the metabolic component of acid-base balance. Metabolic acidosis is characterized by a decrease in standard bicarbonates, and metabolic alkalosis by their increase.

Base excess (*base excess*, BE)

Normal values: **0±2 mmol/l**

Another calculated parameter that evaluates only the metabolic component of acid-base balance. It is defined as the amount of strong acid that would need to be added to the test sample to reach a pH of 7.4, provided that ABR respiratory distress is excluded (ie pCO₂ = 5.3 kPa). In metabolic acidosis, a strong base would need to be added; the corresponding parameter is referred to as ' *base deficit* ', *base deficit* , BD, or (more commonly) is expressed as negative BE.

It is clear from the definition that a negative BE corresponds to metabolic acidosis and a positive BE corresponds to metabolic alkalosis. The parameter is easy to evaluate. In addition, the appropriate composition of infusion solutions for the treatment of the internal environment can be directly calculated from it, especially in the case of metabolic acidoses.

Other ABB parameters

In addition to the listed values, a number of other calculated parameters are defined: strong ion difference (SID), anion gap (*anion gap* , AG), serum buffer bases (BBS) and other. These are parameters that describe the relationship between ABB failure and mineral management. All are defined as the sums and differences of the concentrations of the selected major ions. According to some authors, however, it is more advantageous to directly evaluate the concentrations of individual components of the mineralogram, because the calculation of these parameters loses information.

Evaluation of ABB examination

In general, the following decision algorithm can be used to evaluate the acid-base balance test:

1. 'Is this an ABB fault?'

Is any ABR value outside the reference range?
Can't this be a combined ABB fault (see below)?

2. 'Is the primary ABB disorder acidosis or alkalosis?'

If the current pH is 7.4 (even in the reference range, for example), it will be acidosis, and vice versa, if the pH is 7.4, the primary disorder will be alkalosis.

3. 'Is the primary disorder metabolic or respiratory?'

Respiratory failure corresponds to pCO₂ , metabolic change of standard bicarbonates and BE. The direction must correspond to the previous point. For example, in the previous step, we determined that the primary disorder is acidosis. If pCO is 2 kPa, it is respiratory acidosis; if the standard bicarbonates are 24 mmol / l and BE is negative, it is metabolic acidosis. It can also be a combination of respiratory and metabolic acidosis, but we do not evaluate deviations in the opposite direction in this step.

4. *'Are compensation mechanisms involved?'*
5. . If $p\text{CO}_2$ is within the reference range, we evaluate the disorder as *acute metabolic acidosis* (no respiratory compensation yet). Hypocapnia may be subacute or chronic metabolic acidosis (see below).
6. *'Is the compensation complete?'*

If we determined in the previous step that the ABB compensation deviation is already developing, we evaluate the extent to which it can face the primary failure. If the current blood pH has returned to the reference range, we speak of a "chronic" ABB disorder. If the compensatory mechanisms are obvious, but the pH differs significantly from the norm, we speak of a "subacute" disorder.

Combined ABB disorders

In practice, we often encounter combined ABR disorders. It should be borne in mind that the combination of metabolic acidosis and metabolic alkalosis in particular may remain hidden in the evaluation of the ABR test "according to Astrup", or the severity of the disorder may be underestimated (both disorders correct each other). Information about a combined ABR disorder is crucial, as most treatments affect one component of the combined disorder more quickly than the other; it can then quickly prevail and the patient can get into a severe disruption of the internal environment in a short time.

Therefore, laboratory tests are never evaluated separately - it should always be related to other laboratory findings, medical history and clinical condition. In principle:

- any deviation in the *'principal ion concentration'* (Na^+ , K^+ , Cl^-) causes ABB failure;
- any change in the concentration of *'total protein and albumin'* causes ABB impairment;
- every *'organ failure'* (renal insufficiency, more severe hepatopathy, heart failure) is accompanied by ABB disorder. *'If we expect an ABB disorder based on the anamnesis, clinical picture or other examinations, but we do not "see" it in the ABB examination, it is a combined disorder and we must look for further deviations! If we quickly affect one component of a combined ABB disorder, we must carefully monitor the internal environment and expect it to change rapidly.'*

Source

- www.zdravcentra.cz (<https://www.zdravcentra.cz/index.php?act=bq-31&aid=1&oid=191&OFF=&DIR=&ORD=>)
- <http://public.fnol.cz/www/okb/inf/zad/abr.pdf>

References

- ws:Laboratorní vyšetření acidobazické rovnováhy

1. BURTIS, Carl A, Edward R ASHWOOD a David E BRUNS. *Tietz textbook of clinical chemistry and molecular diagnostics*. 4. vydání. St. Louis, Mo : Elsevier Saunders, 2006. 2412 s. s. 2289. ISBN 978-0-7216-0189-2.

Used literature

- VEJRAŽKA, Martin. *Poruchy acidobazické rovnováhy* [přednáška k předmětu Patobiochemie, obor Všeobecné lékařství, 1. LF UK]. Praha. 7.12.2010.