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Principles of the Cytological-Energy Analysis of the Extravascular Body Fluids

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Introduction

We have investigated development of organ impairment via detection of local inflammatory response in certain extravascular body fluids, for example in the cerebrospinal fluid, in the intraocular fluid, in the pleural effusion in the abdominal effusion, in the peritoneal dialysate, in the synovial fluid etc. We have used the so called cytological-energy principle to analyse these fluids. An impairment of particular organs is usually associated with a local inflammatory response. Its carriers are immunocompetent cells. Therefore the first step is their detection via cytological investigation of certain extravascular fluid.

The further step is an evaluation of immunocompetent cells activation in according to their energy requirement in certain locality [1,2]. Therefore we derived an equation for identifying the theoretical average number of molecules of adenosine triphosphate (ATP) produced from one molecule of glucose under set conditions in certain compartment. We call this parameter the coefficient of energy balance (KEB; in Czech Koeficient Energetické Bilance) [3-5].

Derivation of the KEB (Koeficient Energetické Bilance)

Calculating the KEB originates from three axioms describing glucose metabolism [6,7]:

1. The aerobic production of 38 molecules of ATP from 1 molecule of glucose.
2. The anaerobic production of 2 molecules of ATP from 1 molecule of glucose.
3. The anaerobic production of 2 molecules of lactate from 1 molecule of glucose.

$$x = [glucose]\ [mMol.l^{-1}]$$

$$y = [lactate]\ [mMol.l^{-1}]$$

The number of molecules of glucose metabolized under anaerobic conditions (6 carbon atoms) corresponds to half of the amount of lactate produced (3 carbon atoms):

$$x_{anaerobic} = \frac{y}{2}$$

The calculation above shows that from the total amount of glucose in the extravascular fluid, double the amount of lactate

is produced under anaerobic conditions, which is identical to the amount of produced ATP:

$$[ATP_{anaerobic}] = y$$

The remaining amount of glucose in the extravascular fluid is exchanged aerobically, i.e., 38 ATPs per 1 molecule of glucose:

$$x_{aerobic} = x - x_{anaerobic} = x - \frac{y}{2}$$

$$[ATP_{aerobic}]\ 38(x - \frac{y}{2})$$

The total production of ATP results from the sum of aerobic and anaerobic production:

$$[ATP] = [ATP_{anaerobic}] + [ATP_{aerobic}]$$

$$[ATP] = y + 38(x - \frac{y}{2})$$

The average production of ATP from 1 molecule of glucose represents the resulting KEB value:

$$KEB = \frac{[ATP]}{x}$$

$$KEB = \frac{y + 38((x - \frac{y}{2})}{x} = 38 - 18\frac{y}{x}$$

$$KEB = 38 - 18\frac{[lactate]}{[glucose]}$$

Two models of energy relationships in the extravascular body fluids

The KEB suggests a foundation for two models of the extravascular fluids [4,5]:

Oxygen is diluted in the extravascular body fluids under normal conditions, enabling predominantly aerobic metabolism in the extravascular fluid compartment. This is associated with a relatively high production of ATP, which is expressed as a high KEB value **(Figure 1).**

Pathological changes in the particular organs are usually associated with an immune system reaction **(Figure 2).** Activated immunocompetent cells in the extravascular fluid require increased energy; therefore they consume higher amounts of glucose along with more oxygen. This leads to a decrease in extravascular fluid oxygen and results in anaerobic metabolism with an overproduction of lactate. Anaerobic metabolism is less energy efficient, resulting in decreased ATP production. This is reflected in decreased KEB values.

Cytological-energy findings

1. KEB values >28.0 in the extravascular fluid indicate normal condition, but cannot rule out a possible slight serous inflammation in particular organ [4,5].

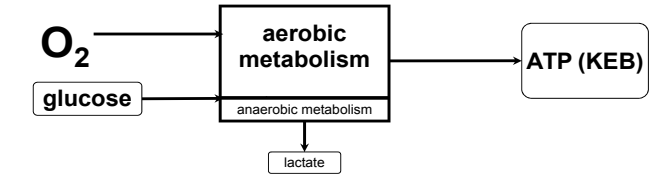

Figure 1 Normal condition.

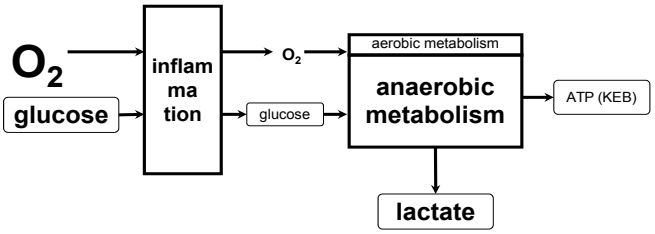

Figure 2 Local inflammatory response.

2. KEB values from 15.0 to 28.0 indicate increased anaerobic metabolism in the extravascular fluid, which may be associated with serous inflammation in particular organ [4,5].
3. A significant number of neutrophil granulocytes and a normal energy relationships (with KEB values >28.0) or higher degree of anaerobic metabolism (with KEB values from 15.0 to 28.0) in the extravascular fluid we call "preventive protection" with an increased risk of purulent inflammation in the particular organ [4,5].
4. A significant number of neutrophil granulocytes and a high degree of anaerobic metabolism (with KEB values <10.0) in the extravascular fluid is typical of purulent inflammation in the particular organ, usually involving extracellular bacteria [4,5].
5. The significant number of lymphocytes or monocyte-macrophages elements and a high degree of anaerobic metabolism in the extravascular fluid (with KEB values <10.0) may signify an intense inflammatory response in the particular organ with an oxidative burst of macrophages, involving intracellular bacteria, mycotic agents or cancer [4,5].

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