USE OF BLOOD GASES AND LACTIC ACID ANALYSES IN DIAGNOSIS AND PROGNOSIS OF RESPIRATORY DISEASES IN CALVES

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Abstract

In calves suffering from chronic bronchopneumonia, marked arterial hypoxaemia (pO₂ near the values normally found in venous blood – 4 up to 6 kPa) accompanied by various degree of hypercapnia was observed. Moreover, hypercapnia and subsequent respiratory acidosis were associated with metabolic compensation - in the most cases blood pH values were found within normal range. Despite apparent clinical improvement of health status during the treatment, values of blood gases showed no or only slight temporary improvement. After the treatment we found worsening of hypoxaemia and hypercapnia. Following our observations, assessment of the diseases by analysis of lactic acid levels in blood serum, showed no marked advantages compared with the blood gases analyses. Higher levels of blood serum lactic acid were recorded only in some cases, particularly in calves near to death.

Key words: calves, blood gases, acid-base balance, lactic acid, respiratory diseases.

Respiratory diseases represent a serious economic problem in cattle rearing. In the strict sense, respiratory syndrome is a complex of mass inflammatory diseases of respiratory organs caused by pathogenic and opportunistic viruses and bacteria in case of adverse environmental conditions and impairment of calves’ immunity (13). Despite a wide knowledge of aetiology, metaphylaxis and prophylaxis, therapeutic effect is often unsatisfactory. Although various forms of calves’ respiratory diseases are known, their clinical manifestation is frequently less differentiated. Because of important role of respiratory system in gas exchange, respiratory diseases may seriously affect body functions, particularly acid-base balance, optimum tissue oxygenation, and elimination of carbon dioxide. In calves suffering from respiratory syndrome, data from the literature indicate various degree of changes in blood gases and disturbances of acid-base balance (3, 9). Occurrence of respiratory acidosis is caused by global respiratory insufficiency (4) and possible decrease in blood pH occurs in this case due to an increase in pCO₂ in the arterial blood and failure of renal regulatory function. In the literature, there are only few data about effects of hypoxaemia on blood lactate levels and, consequently, hypoxaemic lactacidemia and changes in acid-base balance in calves.

Aim of this work was to investigate effects of chronic respiratory diseases on lung functions and degree of compensation of respiratory disturbances by metabolic compartment of acid-base homeostasis in calves. At the same time we studied various degrees of generalized tissue chronic hypoxaemia and their effects on blood serum levels of lactic acid and its potential involvement in changes of acid-base balance.

Material and Methods

In the experiment, 42 calves, hospitalized at the II Clinical Department for Internal Diseases were used. The calves suffered from various forms of respiratory disorders and a practitioner sent them to the clinic because of chronicity and/or relapses of the disease. Holstein black spotted, Slovak spotted and their crossbred calves were from one to seven months old. In the clinic, the calves were individually tethered or placed loosely in pens. Prior to blood collection, the calves were examined by routine clinical methods and treated thereafter.

Following clinical examination, to the observation we included only the calves without any other disease, which might affect the investigated indices. The main criteria for clinical assessment of the severity of respiratory disorders were as follows:

– general state – case history, behaviour and responses to surroundings, feed intake, body temperature, body condition
– clinical findings in the respiratory system obtained by inspection (breathing, discharge from nostrils, dyspnoea, cough, additional respiratory movements) and by auscultation (type, extent, character, and
intensity of respiratory sounds, adventitious respiratory sounds)

Blood samples for the examination of acid-base balance were collected by direct puncture of the a. axillaris into 1 ml plastic syringes (Radiometer Copenhagen) (8). Dead space of the syringe was filled with heparin solution at the concentrations of 500 I.U. per ml of blood. The samples were analysed within 15 min after the collection with the use of ABL 5 instrument (Radiometer Copenhagen). We evaluated the following indices: blood pH, partial pressure of carbon dioxide – pCO₂, partial pressure of oxygen – pO₂, concentration of actual bicarbonate – AB, base excess – BE, and saturation of haemoglobin by oxygen – O₂-sat.

Blood samples for the determination of lactate concentrations were collected from the v. jugularis. To prevent glycolysis, NaF was used as a stabilizer. Lactate concentration were analysed by an enzymatic method with the use of an automatic biochemical analyser ALIZÉ (Lisabio, France) and test kits (BioMérieux).

The achieved results were evaluated in two groups of calves:
- group RD (n=35); in this group, blood samples were collected at the beginning of observation, after clinical examination or during the therapy, i. e. more than 24 h before the death or before returning to the owner;
- group RD 24 (n=7); this group consisted of calves, which died within 24 h after the blood collection.

Treatment efficiency was evaluated simultaneously. Some calves died during the hospitalization, in others clinical state and laboratory results after the end of therapy were evaluated. Following assessment of response to treatment, the calves were sent back to their owner with the statement of prognosis – either favourable or unfavourable. Animals with unfavourable prognosis were recommended to be culled from a herd.

Statistical analyses of the obtained results were done by computer programme (Instat Graph Pad v. 2.04) including mean values and standard deviations within the groups of calves. Significance of differences between the groups (P) was assessed by Student’s t- test.

Results

The obtained results in the two groups of calves are presented in Table 1 including mean, minimum, and maximum values, standard deviations, and significance of differences between the groups.

In both groups, mean blood pH ranged within the reference limits, however, in calves which died within 24 h, blood pH was significantly lower (P<0.05). In the group RD, lower individual values in the range of acidemia (pH<7.35) were found in 3 calves (8.6 %), and in 9 calves (27.7 %) in the range of alkalaemia (pH>7.44). In the group RD 24, acidemia was recorded in 3 calves, and alkalaemia only in 1 calf.

When evaluating pCO₂, in the group RD mean value 6.5 kPa, and in the group RD 24 7.7 kPa were recorded and in both groups the pCO₂ values corresponded to the values in the range of hypercapnia. This difference was highly significant (P<0.05). In the group RD, individual pCO₂ values higher than those in normocapnia (over 6 kPa) were found in 24 animals (68.6%), marked hypercapnia (pCO₂>8 kPa) was recorded in 4 calves (11.4%) with maximum value 8.9 kPa. In the group RD 24, marked hypercapnia was found in 4 calves (57.1%) with maximum individual value 12.5 kPa.

In both groups, pO₂ values mostly indicated marked hypoxaemia, in average 6.6 kPa in the group RD and only 4.3 kPa in the group RD 24 (P<0.01). Severe hypoxaemia with individual pO₂ values below 5.5 kPa (corresponding to oxygenation of venous blood collected from v. jugularis) was observed in 12 calves (34.3%) in the group RD and in 6 calves in the group RD 24 (85.7%).

Evaluation of partial pressures of blood gases revealed global respiratory insufficiency in 24 calves in the group RD and in 4 calves in the group RD 24.

Similar trend as in pO₂ was recorded also for O₂-sat, when average O₂-sat values in the group RD reached 81%, while in the group RD 24 only 53%, which represented highly significant difference between the groups (P<0.001). Evaluation of individual values in the group RD showed O₂-sat values below 90% in 30 calves (85.7%), and below 75% in 12 calves (34.3%). In the group RD 24, except one calf, O₂-sat values below 70% were observed with the minimum values 25%.

Table 1

Mean values of blood gases, acid-base balance, and lactate in calves with respiratory syndrome

<table>
<thead>
<tr>
<th>Group of calves</th>
<th>pH</th>
<th>pCO₂ kPa</th>
<th>pO₂ kPa</th>
<th>AB mmol/l</th>
<th>BE mmol/l</th>
<th>O₂-sat %</th>
<th>lactate mmol/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD</td>
<td>7.41±0.05</td>
<td>6.5±1.0</td>
<td>6.6±1.4</td>
<td>30.2±3.7</td>
<td>4.8±3.3</td>
<td>81±11</td>
<td>1.29±0.53</td>
</tr>
<tr>
<td>min.</td>
<td>7.24</td>
<td>5.0</td>
<td>4.1</td>
<td>24</td>
<td>-3</td>
<td>54</td>
<td>0.64</td>
</tr>
<tr>
<td>max.</td>
<td>7.48</td>
<td>8.9</td>
<td>9.1</td>
<td>39</td>
<td>11</td>
<td>94</td>
<td>3.1</td>
</tr>
<tr>
<td>RD 24</td>
<td>7.36±0.07</td>
<td>7.7±2.5</td>
<td>4.3±1.8</td>
<td>30.4±5.6</td>
<td>3.7±2.9</td>
<td>53±21</td>
<td>2.78±1.1</td>
</tr>
<tr>
<td>min.</td>
<td>7.24</td>
<td>4.6</td>
<td>2.6</td>
<td>23</td>
<td>-1</td>
<td>25</td>
<td>0.88</td>
</tr>
<tr>
<td>max.</td>
<td>7.46</td>
<td>12.5</td>
<td>8.2</td>
<td>39</td>
<td>7</td>
<td>92</td>
<td>4.93</td>
</tr>
<tr>
<td>P &lt;</td>
<td>0.05</td>
<td>0.05</td>
<td>0.01</td>
<td>n.s.</td>
<td>n.s.</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

± – standard deviation, P < – significance of the difference between the groups, n.s. – not significant.
Evaluation of metabolic compartment of acid-base balance characterized by values of AB and BE showed similar tendency, particularly at higher concentrations (characteristic for metabolic alkalosis) compared with physiological values. The observed mean AB values in the group RD (30.2 mmol/l) and in the group RD 24 (30.4 mmol/l) did not differ significantly. Similar insignificant differences between mean BE values in both groups were recorded (4.8 and 3.7 mmol/l, respectively). Higher individual AB values (over 27 mmol/l) were found in 28 calves (80%) in the group RD and 4 calves (57.1%) in the group RD 24. Lower bicarbonate concentrations characteristic for acidosis were not recorded.

Except 3 calves, in the group RD, individual levels of lactate ranged within physiological values (up to 2.2 mmol/l). The maximum lactate concentration in this group reached 3.1 mmol/l. Mean lactate concentration in the group RD was 1.29 mmol/l. In the group of calves shortly before death (RD 24) mean lactate concentration 2.78 mmol/l was found, and higher individual values were recorded in 6 calves, when the highest concentration reached 4.93 mmol/l. Differences between the mean lactate concentrations in the two experimental groups were highly significant (P<0.001).

Among the calves in the group RD, 12 animals (34.3%) died during hospitalization, the remaining calves showed improvement of clinical findings, however, blood gases values in 16 animals (45.7%) showed only varying mild improvement. Therefore, these calves were sent to the owner with unfavourable or doubtful prognosis. Among total number of calves (n=35) in this group, general clinical improvement and restoration of lung functions with favourable prognosis were observed only in 7 calves (20%).

Discussion

Despite large scale of possible pathogens, clinical picture of respiratory diseases in calves is almost uniform. Because of this uniform symptomatology, differential diagnosis should be focused on disease localization, severity, as well as intensity of its course (6). Clinical examination represents only the starting point in diagnosing the lung diseases resulting in symptomatic diagnosis and only partial evaluation of disease severity (5). However, it is difficult or even impossible to assess sufficiently morphological and functional changes by clinical examination. Therefore, there is a need for other additional specific examination methods (1) Analysis of gases in the arterial blood is an important tool in evaluating lung dysfunctions; it is the base of respiratory functional diagnosing (9). Several authors incline to the opinion that particularly pO2 values offer the most sensitive evaluation of the presence and severity of respiratory disease (12). Compared with pCO2, pO2 changes even in mild lung affections and disturbances in gas exchange. Because over 95% of oxygen is delivered to tissues by oxyhaemoglobin, the saturation is of the greatest clinical significance. Decreased delivery to the brain or heart can lead to collapse, and decreased delivery to other tissues leads to lactic acidosis and metabolic abnormalities (7). Metabolic indices of acid-base balance reflect possible compensating regulatory processes in the body as a response to disturbed homeostasis due to development of respiratory acidosis.

Our results presented in calves with chronic bronchopneumonia correspond to commonly reported findings of decreased pO2 and O2-sat., i.e. hypoxaemia in calves suffering from respiratory disease. The results confirm also findings of different pCO2 values (both higher and lower values) reported in the literature in such calves. On the one hand, decrease in pCO2 is ascribed to tachypnoe and hyperventilation, which are frequently observed in affected calves (15). On the other hand, increase in pCO2 results from extensive damage to lung parenchyma with disturbed elimination of CO2 in the cases of large atelectases, exudative pneumonia, and obstructive bronchiolitis (14). Our experiences indicate that hypoxaemia and hypercapnia manifest severe form of respiratory disease with marked disorders of ventilation, perfusion, and diffusion of blood gases accompanied frequently (despite the treatment) by death or culling of such animals. In the literature, there are few reports on effects of hypoxaemia, particularly of chronic hypoxaemia, on the level of lactic acidemia in calves. Up to now, our result correspond to those reported by Coghe et al. (2), who observed increased blood lactate levels in calves with respiratory disease within 24 h before the death. They found that plasma lactate concentration higher than 3.6 mmol/l measured with the reference method appeared to be a reliable prognostic indicator for mortality within 24 h. In our experiment, lactate concentrations recorded mainly within the reference range during the treatment (or more than 24 h before death, resp.) indicate that (despite lower content of O2 in the arterial blood) under relatively quiet conditions the animal body is adequately saturated with oxygen. This is a reflection of compensatory involvement of the respiratory and circulatory systems (10).

Our observations and experiences indicate that analyses of blood gases (pO2 and pCO2) in arterial blood serve as important indices of severity, therapeutic effectiveness, and prognosis of respiratory diseases. In calves suffering from chronic bronchopneumonia, we found marked hypoxaemia (pO2 near the values normally found in venous blood – 4 up to 6 kPa) accompanied by various degree of hypercapnia, which corresponds to global respiratory insufficiency. Moreover, hypercapnia and subsequent respiratory acidosis were associated with metabolic compensation (increased levels of bicarbonates and BE). Therefore, in the most cases, blood pH values were found within normal range regardless of the disease severity. Despite apparent clinical improvement of health status during the treatment, values of blood gases showed no or only slight temporary improvement. After the treatment, even in cases with long lasting therapy, we found worsening of hypoxaemia and hypercapnia. Following our observations, assessment of the diseases by analysis of lactic acid levels in blood serum, showed no marked
advantages compared with the blood gases analyses. Higher levels of blood serum lactic acid were recorded only in some cases, particularly in calves near to death. Its prognostic importance thus consists in indication of possible death within 24 h. Together with blood gases analyses, it may help in decision about starting the treatment and its effectiveness contributing thus to the reduction of therapeutic costs in animals with unfavourable prognosis.

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References