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Original article

An analysis of pH, pO_2 and pCO_2 in the peritoneal fluid of dogs with ascites of various etiologies

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Abstract

The aim of the study was to assess pH, pO_2 and pCO_2 in peritoneal fluid. The study was conducted on a group of 22 dogs with symptoms of ascites. Group 1 consisted of 4 dogs with adenocarcinoma, group 2 – of 6 dogs with glomerulonephritis, group 3 of 8 dogs with hepatic cirrhosis and group 4 of 4 dogs with bacterial peritonitis. An abdominal cavity puncture was performed in all dogs and the fluid was drawn into a heparinized syringe in order to assess pH, pO_2 and pCO_2. The analysis of pH in the peritoneal fluid revealed statistically significant differences between group 4 and groups 1 ($p=0.01$), 2 ($p=0.01$), and 3 ($p=0.01$). The lowest pH value compared to the other studied groups was recorded in group 4. In group 4, the pO_2 was the lowest compared to the other groups (group 1 $p=0.01$, group 2 $p=0.01$, group 3 $p=0.01$). The value of pCO_2 was the highest in group 4 compared to groups 1, 2, and 3. The study found statistically significant differences in pH, pO_2 and pCO_2 between group 4 (the group of dogs with bacterial peritonitis) and the other groups of dogs. This was probably linked to the pathogenesis of peritonitis. As a result of an inflammatory reaction within the peritoneal cavity, there is an increase in fibrin accumulations leading to a decreased oxygen supply causing the oxidative glucose metabolism to change into a non-oxidative glucose metabolism. This, in turn, causes a decrease in pH, acidosis, and a low oxidoreduction potential. It also impairs phagocytosis and activates proteolytic enzymes which create ideal conditions for the growth of anaerobic bacteria. The obtained results indicate that the pH, pO_2 and pCO_2 may be used to differentiate bacterial peritonitis from ascites of other etiologies.

Key words: ascites, dogs, acid-base parameters, peritoneal fluid

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Introduction

Ascites is a symptom of numerous diseases of various etiologies. The most frequent causes of the accumulation of fluid in the peritoneal cavity are: chronic circulatory failure, cancer, liver diseases, infectious peritonitis, hypoalbuminemia related to intestinal malabsorption and excess protein loss in urine (King and Gelens 1992, Alleman 2003, Glińska 2009). The examination of peritoneal fluid and its in-depth analysis is essential to determine the cause of an accumulation of fluid in the peritoneal cavity. It also provides valuable information that enables the evaluation of the mechanisms of the formation of ascites. In human medicine, studies aiming to assess pCO_2 in fluid drawn from the peritoneal cavity in the course of cancer has been conducted (Vaupel and Hockel 1993, Simmen and Blaser 2001, Noh 2003). In veterinary medicine such studies have not been carried out. Therefore, we attempted to assess particular parameters of the acid-base balance in the peritoneal fluid in dogs with ascites of various etiologies.

The aim of the study was to assess the pH and analyse the partial pressure of pO_2 and pCO_2 in the peritoneal fluid in dogs with ascites of various etiologies.

Materials and Methods

The study was conducted on a group of 22 dogs of various breeds (8 German shepherds, 6 mixed breed dog, 5 boxers, 3 labrador retrievers) and of both genders (15 males, 7 females) between 2 and 10 years-old with symptoms of ascites.

The dogs were patients for the Veterinary Clinic of the Department of Internal Diseases with Clinic for Horses, Dogs and Cats of the Wroclaw University of Environmental and Life Sciences.

All dogs had an enlarged abdominal cavity. A decrease in physical activity was reported in 18 dogs. 12 dogs had a mixed inspiratory and expiratory dyspnoea and 2 dogs had a prolonged cough. The dogs were divided into four groups based on the results of the clinical examination, laboratory blood tests, the peritoneal fluid examination (physicochemical properties, biochemical parameters, cytology and microbiological testing) as well as the results of ultrasonography, an X-ray examination, and a histopathological examination. Group 1 consisted of 4 dogs with ascites caused by an adenocarcinoma, group 2 included 6 dogs with glomerulonephritis causing fluid accumulation, group 3 contained 8 dogs with hepatic cirrhosis and group 4 included 4 dogs with bacterial peritonitis causing ascites.

The abdominal cavity drainage was performed in all dogs. During the drainage, about 3 ml of fluid was drawn into a heparinized syringe equipped with a needle with an internal diameter of 0.7 mm. The values of pH, pO_2 and pCO_2 were determined in a sample of the fluid drawn by means of the Osmetech OPTI Blood Gas Analyser apparatus. The peritoneal fluid was drawn without exposure to air and the collected material was delivered to the laboratory within 3-5 minutes.

Statistical analysis was performed using version 10 of STATISTICA (StatSoft Inc., Poland). Data were expressed as mean values. The correlation between pH, pO_2 and pCO_2 values were determined using the Spearman correlation. A p-value of ≤ 0.05 was considered statistically significant.

Results

Mean values and standard deviations of the parameters of the ascitic fluid examined in the particular groups of dogs are presented in Table 1.

On the basis of the analysis of the pH of the peritoneal fluid, statistically significant differences were found between group 4 and groups 1 ($p= 0.01$), 2 ($p=0.01$) and 3 ($p=0.01$) (Fig. 1). In group 4, the pH value was lower than in the other groups. There were also statistically significant differences between group 3 and group 1 ($p=0.26$) and group 2 ($p=0.04$) (Fig. 1).

The partial pressure of pO_2 was the lowest in group 4 compared to the remaining groups (group 1 $p=0.01$, group 2 $p=0.01$, group 3 $p=0.01$) (Fig. 2). Statistically significant differences in the partial pressure of pO_2 were also found between group 1 and groups 2 and 3 as well as between groups 2 and 3 (Fig. 2).

In turn, the analysis of the partial pressure of pCO_2 showed statistically significant differences between all the examined groups (group 1 vs. group 2 $p=0.01$; group 1 vs. group 3 $p=0.01$; group 1 vs. group 4 $p=0.01$, group 2 vs. group 4 $p=0.01$, group 3 vs. group 4 $p=0.01$) (Fig. 3).

Discussion

In the present study, statistically significant differences in pH, pO_2 and pCO_2 were noticed between group 4 (a group of dogs with bacterial peritonitis) and the remaining groups of dogs. Those differences are likely linked to the pathogenesis of peritonitis. In the course of peritonitis, fibrin, which accumulates on the peritoneum, reduces the penetration of bacteria,

Table 1. Mean values and standard deviation of the parameters of the ascitic fluid examined in the particular groups of dogs.

	Mean value	Standard deviation
Ascites fluid pH gr 1	7.455	0.025
Ascites fluid pH gr 2	7.49	0.064
Ascites fluid pH gr 3	7.41	0.04
Ascites fluid pH gr 4	7.045	0.045
Ascites fluid pO_2 gr 1 [mmHg]	89	14.5
Ascites fluid pO_2 gr 2 [mmHg]	91.66	5.95
Ascites fluid pO_2 gr 3 [mmHg]	82.33	22.69
Ascites fluid pO_2 gr 4 [mmHg]	18.25	2.5
Ascites fluid pCO_2 gr 1 [mmHg]	49.25	1.89
Ascites fluid pCO_2 gr 2 [mmHg]	33.5	3.14
Ascites fluid pCO_2 gr 3 [mmHg]	39.66	6.62
Ascites fluid pCO_2 gr 4 [mmHg]	100.5	3.10

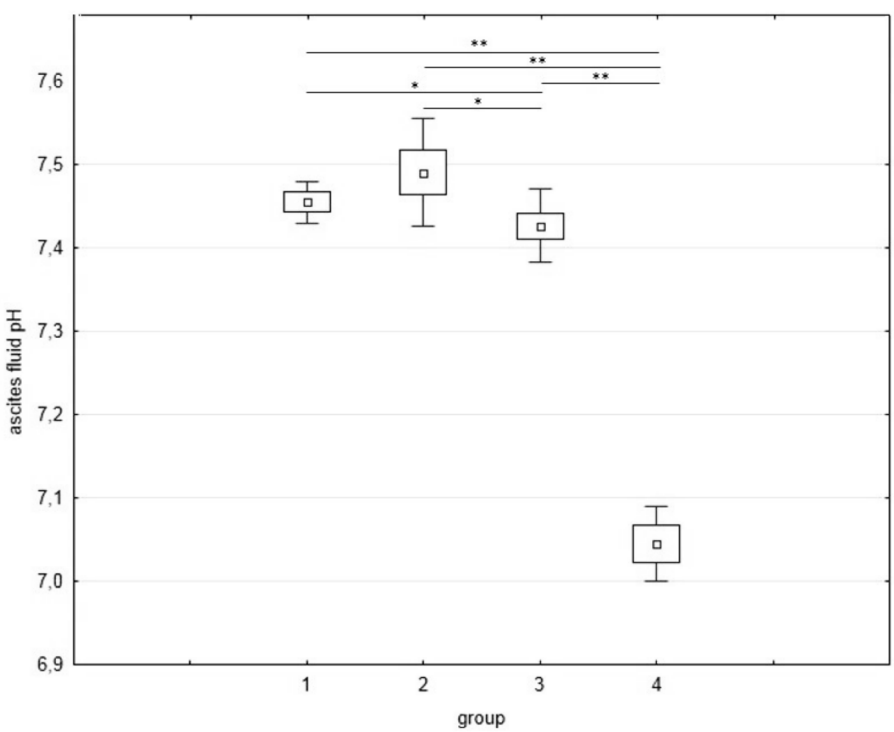

Fig. 1. Graph demonstrating the comparison of the pH of the peritoneal fluid in 4 groups of examined dogs.
** < p=0.01, * < p= 0.5

their toxins and metabolites from a site of infection into the bloodstream as well as the penetration of the cells of the immune system and nutrients to the location of the infection. A reduced blood supply to the peritoneum, which results from fibrin accumulation, causes a transformation from aerobic glycolysis to anaerobic glycolysis. As a consequence, pH decreases. Acidosis, a low oxidoreduction potential, impaired phagocytosis and activation of proteolytic enzymes are observed. That creates ideal conditions for the growth of non-oxidative bacteria. In the available literature, there is little information on the changes of the studied parameters in the peritoneal fluid in the course of the peritonitis (Hosgood and Salisbury 1989). The studies differ significantly with regard to the method and way of fluid collection. In most of the studies, the fluid was not drawn in strictly oxygen-free conditions, as in our study, so the results may be inac-

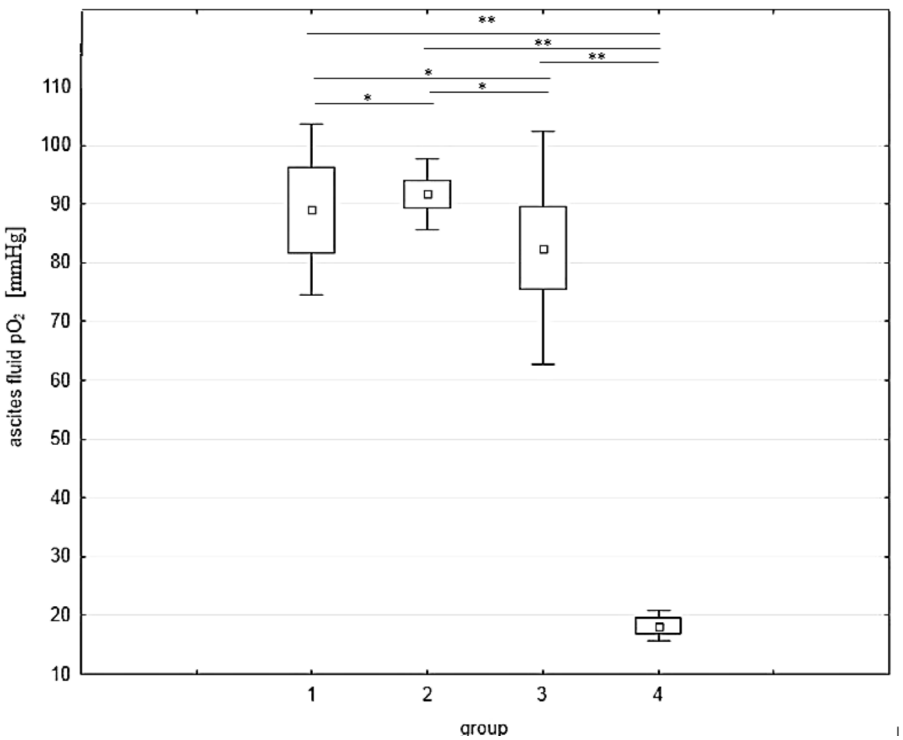

Fig. 2. Graph demonstrating the comparison of pO_2 of the peritoneal fluid in 4 groups of examined dogs.
** < p=0.01, * < p= 0.5

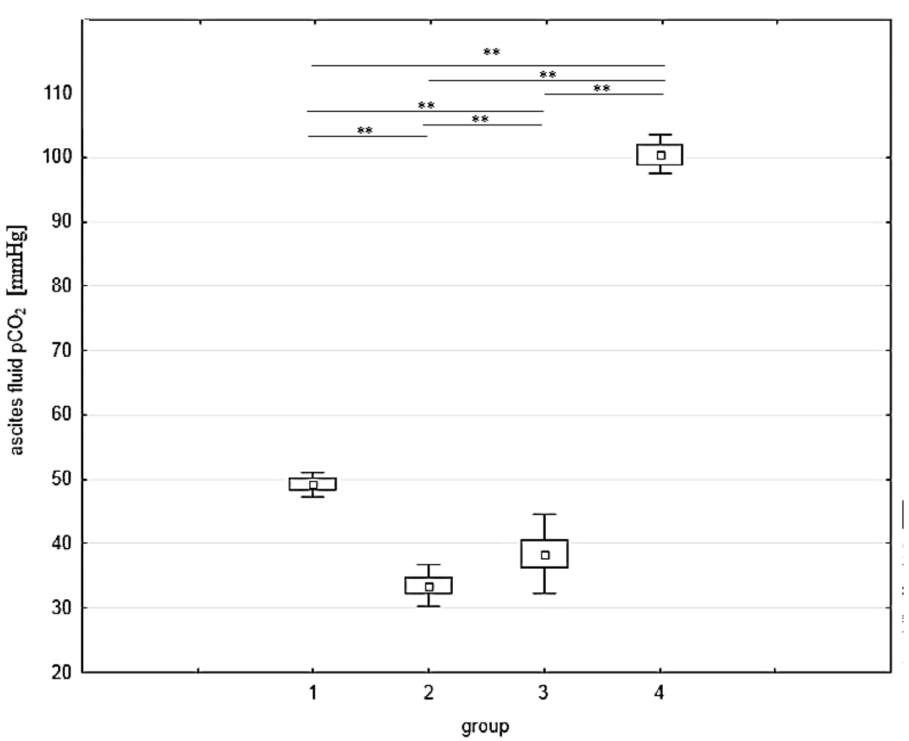

Fig. 3. Graph demonstrating the comparison of pCO_2 of the peritoneal fluid for 4 groups of dogs.
** < p=0.01, * < p=0.5

curate (Vaupel and Höckel 1993, Simmen and Blaser 2001, Noh 2003). In the study carried out by Simmen and Blaster (1993) aiming to assess pO_2 in peritoneal fluid, the authors obtained similar results, on the basis of which they stated that there is a significant decrease in the value of pO_2 in the peritoneal fluid in the case of ascites caused by peritonitis. In turn, Sheckman et al. (1977) carried out a study which assessed the value of pO_2 in patients with liver cirrhosis. On the basis of their results, they stated that the value of pO_2 in the studied group is very high, which reduces the possibility of spontaneous peritonitis in those patients. In our study, the value of pO_2 in the peritoneal fluid in dogs with liver cirrhosis was also very high. However, it did not differ significantly from the value of pO_2 in dogs with cancer and renal failure. In 2010, a team of Japanese scientists assessed pO_2 in the peritoneal fluid collected from patients with metastatic stomach cancer (Emoto et al. 2010). They found that a very high value of oxygen in the peritoneal fluid occurred in the course of ascites caused by metastatic malignant stomach cancer. They suggested that this finding may be linked to an increase in the secretion of vascular endothelial growth factor by the cancer, which causes an increased vascular permeability and enables an efficient supply of oxygen to the peritoneum. That supports the survival of metastatic cancer cells in the abdominal cavity. In our study, the value of pO_2 in dogs with cancer was also high. However, it did not differ significantly from the values obtained in patients with glomerulonephritis.

There was a significant decrease in the pH of the peritoneal fluid in group 4 as well as a significantly lower value of pH in group 3 compared to groups 1 and 2.

To date, there is no thorough analysis of the significance of the fluid pH on the diagnosis of ascites in dogs in veterinary literature. In human medicine, a number of studies focusing on the variability of pH in fluids from body cavities have been carried out (Gitlin et al. 1982, Sahn and Good 1988, Simmen and Baser 1993, Simmen and Blaser 2001, Bonczynski et al. 2003, Noh 2003). According to Light (1972), a decrease in the pH of the fluid in the pleural cavities is observed in inflammatory conditions, cancers, acidosis or lupus. Sahn and Good (1988) carried out a study that proved that a decrease in the pH was found in cancers. In our study, differences in the pH of the fluid between group 1 and 2 were weakly significant. Unlike the results of the studies obtained in human medicine, they did not allow the differentiation between the group of dogs with ascites caused by cancer and that of dogs with chronic renal failure and liver cirrhosis.

Based on the results of our study, we found that the pH and pO_2 were lower in the ascitic fluid of dogs with bacterial peritonitis than in the fluid of dogs with an adenocarcinoma, glomerulonephritis or hepatic cirrhosis. We also observed higher pCO_2 values in dogs with fluid accumulation caused by bacterial peritonitis than in the remaining groups of dogs. Our results indicate that the pH, PO2 and PCO2 may be used to differentiate ascites caused by bacterial peritonitis from ascites of other etiologies.

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