Relationship between claw disorders and metabolic disturbances in dairy cattle[1]

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Summary

The study was performed on a total number of 143 dairy cows affected by both claw disorders and metabolic disturbances. It was found that, in cows affected by claw disorders associated with alkalosis, the average proportion of segmented neutrophils, CK activity, GLDH activity and TP were significantly higher. In cows associated with primary acetonaemia, the proportion of eosinionphils and the CK activity were significantly higher. In hypocalcemia the haematocrit value and Ca level was significantly lower, whereas the total leukocytic count, segmented neutrophils, and urea were significantly higher than normal. In hypophosphatemia the average P was significantly lower, whereas the average CK and bilirubin were significantly higher. In cows associated with hypomagnesemia the proportion of segmented neutrophils, CK activity, GLDH, TP and bilirubin were significantly higher, whereas the average Mg was significantly lower. In cows affected by fat cow syndrome the proportion of segmented neutrophils, GLDH activity and TP value was higher than normal. It was concluded that, the metabolic and microcirculatory changes associated with ruminal acidosis, acetonaemia, fatty liver, hypocalcemia, hypophosphatemia and hypomagnesemia leading to ischemic necrosis and degeneration of the horn producing structures and destruction of the connection between claw horn and corium predisposing to claw affections.

Introduction

The horn quality of the claws appear to be affected very much by the animal's metabolism. Metabolic changes may predispose to the occurrence of chronic necrotic pododermatitis (Greenough, 1962).

The trigger mechanism is thought to be in the digestive tract. Absorption of toxic fermentation products into the circulation brings the action to the burdened pododerm. Damage of this tissue manifests itself in a latter stage in the claw sole (Peterse, 1987).

Laminitis arising from a systemic disorder due to a wide spectrum of probably largely interdependent aetiological factors. These varies from systemic influences such as metabolic and digestive disorders, calving or severe inflammatory processes (e.g. endometritis or mastitis) to localized influences in the claw. However, all have something in common; in a first phase, predominantly vasoactive substances which have been released into the circulatory system, may trigger pathological mechanisms which ultimately cause degenerative changes in the epidermal-dermal junction of the claw (Baggott, D.G., 1982 and Ossent, P. and Lisher, C., 1994).

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The following three factors were suggested to be important in triggering the changes in the claws: (a) endotoxin released from inflammatory foci and endotoxaemia, (b) lactic acid in relation to ruminal acidosis and (c) histamine, released in allergic reactions are absorbed from the gut (Bossman, 1990 and Vermunt, 1994).

The aim of the present study is to search in the causes of claw affections combined with metabolic disturbances in dairy cows through examination of total blood picture, biochemical blood parameters, acid - base balance, blood clotting profile, urine and ruminal fluid.

Material and methods

The study was performed on a total number of 143 cows affected by both claw disorders and metabolic disturbances. From these cows 110 one were examined for total blood picture, biochemical blood parameters, urine and ruminal fluid. Another 21 cows examined for blood clotting profile and another 12 cows for acid-base balance. All cows were examined for claw status.

Claw examination:

To determine the site of lesion, the claw was examined routinely by cleaning, manual palpation, pressure test, percussion, paring the horn and probing (Rosenberger et al, 1979). Dignosis of claw affections was based on the clinical signs and symptoms as defined in literature particulary the observations of Weaver et al (1981).

Blood examination:

Blood samples were taken in two tubes one containing EDTA for whole blood collection, the other being for serum.

Total blood picture: haemoglobin, haematocrit, erythrocytic and total leukocytic count were determined in an automatic microprocessor - based haematology analyzer. The proportion of eosinophils, basophils, unsegmented, segmented, juvenile and immature neutrophils, lymphocytes and monocytes were calculated manually by counting 100 leukocytic cells in zigzag manner in different microscopic fields and calculate the percentage of each type.

Blood biochemical parameters: Serum Ca and Mg were determined in an atomic absorption spectrophotometer. Serum sodium and potassium were determined, quantitatively, in an Electrolyte Analyzer. Serum inorganic phosphorus, aspartate aminotransferase, creatin kinase, glutamat-dehydrogenase, gamma glutamyl transferase, total protein, bilirubin and urea values were determined in an auto - analyzer.

Blood clotting profile: Two blood samples were taken , one containing sodium citrate and the other whole blood. The blood platelets was counted in an automatic microprocessor-based haematology analyzer. The Coagulometer was used for determination of recalcification time, partial plasma thromboplastin time (PTT), plasma thromboplastin time (TPT), plasma thrombin time (TT) and fibrinogen. Recalcification time was determined chemically (200 µl citrated blood (1 : 9), 1 minute prewarming and with 200 µl 0,025 molar Calcium chloride mixing). The Thromboplastogram reaction time (TEGr), clot formation time (TEGkt) and maximum amplitude (TEGma) were determined in Thromboplastograph-D.

Acid - base balance: Blood samples were taken on heparin and transfered in ice. Acid -base balance parameters were determined in an automatic blood gas analyzer. The examined parameters are: hydrogen ion concentration (pH), carbon

dioxide tension *(p*CO2), oxygen tension *(p*O2) concentration of hydrogen carbonate (HCO3-) and actual base excess (ABE).

Urine examination:

Urine was examined for colour, specific gravity, pH, protein, ketone bodies, glucose, bile pigments and haemoglobin and red blood cells (Combur test).The judgment of the examined parameters depends on the colour of the reaction (Rosenberger et al, 1979).

Ruminal fluid examination:

The ruminal fluid was examined directly for colour, odour, viscosity, pH, sedimentation and floatation activity, methylene blue reduction test and infusoria (Rosenberger et al, 1979).

Statistical analysis of the data was done by Analysis Of Variance (ANOVA) using Statistical Analysis Systems (SAS Institute Inc., 1992). The data were presented as mean ± standard error and the difference considered significant at $p<0.05$ and Highly significant at $p<0.01$.

Results

The encountered claw affections diagnosed with the different metabolic disturbances are pododermatitis aseptica diffusa (11), pododermatitis circumscripta non-purulenta (28), pododermatitis circumscripta purulenta (30), pododermatitis septica profunda (14), subclinical laminitis (12), podoarthritis (4), os pedis necrosis (4), phlegmona interdigitalis (7), dermatitis digitalis (4), dermatitis interdigitalis (8), hyperplasia interdigitalis (4), erosio ungulae (8), vertical crack (3), toe ulcer (3) and overgrown claws (3).

The results of the total blood picture showed that, in cows affected by alkalosis (abomasal displacement) associated with claw disorders, the proportion of segmented neutrophils was significantly ($p<0.05$) higher. In primary acetonaemia, the proportion of segmented neutrophils and eosinophils were significantly ($p<0.05$) higher. In hypocalcemia, the average haematocrit value, erythrocytic count and proportion of lymphocytes were significantly ($p<0.05$) lower. In hypophosphatemia, the average proportion of segmented neutrophils was significantly ($p<0.05$) higher whereas, the average haematocrit value was significantly ($p<0.05$) lower. In hypomagnesemia, the average total leukocytic count and the proportion of segmented neutrophils were significantly ($p<0.05$) higher whereas the average haematocrit value was significantly ($p<0.05$) lower. In fatty cow syndrome, the average total leukocytic count and the proportion of segmented neutrophils were significantly ($p<0.05$) higher whereas, the average haematocrit value was significantly ($p<0.05$) lower (table 1).

Table 1: Total blood picture.

Parameter	Alkalosis (N= 66)	Primary Acetonaemia (N= 16)	Hypoc-alcemia (N= 2)	Hypopho-sphatemia (N= 5)	Hypoma-gnesemia (N= 8)	Fat Cow Syndrom e (N= 6)	*Normal range*
Hb (g/l)	100 ±3.14	107.4 ±7.56	94.5 ±9.65	111.8 ±13.25	101.4 ± 17.41	96.5 ± 6.87	*80 - 120*
Hkt (l/l)	0.3 ±0.04	0.323 ±0.21	0.265 ± 0.05*	0.284 ±0.08	0.287 ± 0.06	0.29 ±0.04	*0.30 - 0.40*
RBCs (T/l)	5.96 ±2.52	6.114 ±2.01	4.88 ± 1.08	5.952 ±1.02	6.027 ±2.47	5.86 ±3.21	*5 - 8*
WBCs (G/l)	9.81 ±4.12	9.187 ±3.04	13.2 ± 3.01*	8.32 ±2.14	10.86 ±3.45	10.92 ±4.78	*5 - 10*
Eos. (%)	2.621 ±0.56	6.125 ± 1.56 *	2 ±0.01	0.2 ±0.03	2.375 ±1.98	1.5 ±0.74	*0 - 3*
Baso. (%)	0.06 ±0.001	0.25 ±0.23	0	0	0.125 ±0.74	0	*0 - 5*
Unseg. (%)	2.469 ±1.02	3.75 ±1.94	2 ±0.1	1.4 ±0.04	4.75 ±1.96	2.333 ±0.58	*0 - 5*
Seg. (%)	53.53 ± 6.32 *	43.44 ±8.41	58.5 ± 11.4*	44.4 ±4.79	48.63 ± 7.96*	54.83 ± 9.45*	*20 - 40*
Lym. (%)	40.98 ±4.56	46 ±9.54	37.5 ±8.64	54 ±14.32	43.75 ±13.24	41.17 ±15.41	*40 - 80*
Mono. (%)	0.196 ±0.21	0.321 ±0.01	0	0	0.375 ± 0.08	0.166 ±0.07	*0 - 5*
Juv. (%)	0.06 ±0.01	0.125 ±0.02	0	0	0	0	*0 - 5*

Biochemical blood analysis revealed that, in cows affected by alkalosis (abomasal displacement) associated with claw disorders, the average CK, GLDH and TP values were significantly ($p<0.05$) higher. In primary acetonaemia, the average CK and GLDH values were significanatly ($p<0.05$) higher. In hypocalcemia, the average urea was significantly ($p<0.05$) higher whereas, the average Ca was significantly ($p<0.05$) lower. In hypophosphatemia, the average CK, TP and bilirubin values were significantly ($p<0.05$) higher whereas, the average P was significantly ($p<0.05$) lower. In hypomagnesemia, the average CK, GLDH, TP and bilirubin values were significantly ($p<0.05$) higher whereas, the average serm Mg value was significantly ($p<0.05$) lower. In fatty cow syndrome, the average AST, GLDH and TP values were significantly ($p<0.05$) higher (table 2).

Table 2: Blood serum biochemical parameters.

Parameter	Alkalosis (N= 69)	Primary Acetonaemia (N= 16)	Hypoc-alcemia (N= 3)	Hypopho-sphatemia (N= 6)	Hypomag-nesemia (N= 10)	Fat Cow Syndrome (N= 6)	*Normal range*
Ca (mmol/l)	2.249 ± 0.45	2.205 ±1.4	1.75 ± 0.57*	2.168 ±1.07	2.222 ±0.97	2.376 ±1.02	*2 - 3*
P (mmol/l)	1.576 ±0.67	1.64 ±0.94	1.93 ±0.34	0.803 ± 0.54*	1.433 ±0.56	1.511 ±0.84	*1.30 - 2.20*
Mg (mmol/l)	0.825 ±0.16	0.838 ±0.24	0.726 ±0.27	0.786 ±0.34	0.519 ± 0.14*	0.696 ±0.34	*0.60 - 1.30*
Na (mmol/l)	138.7 ±15.42	137.8 ±24.57	136.2 ±20.89	142.5 ±30.47	139 ±25.10	137.7 ±14.79	*130 - 150*
K (mmol/l)	3.982 ±1.90	3.945 ±1.27	4.12 ±1.65	4.59 ±0.98	3.765 ±1.02	3.843 ±1.56	*4.0 - 5.0*
AST (IU/l)	72.09 ±6.57	54.63 ±6.78	52.33 ±8.79	71.33 ±8.97	79.6 ±9.24	106.2 ±18.75	*0 - 100*
g-GT (IU/l)	20.41 ±3.45	14.14 ±5.89	18.91 ±6.54	12.5 ±3.78	17.22 ±7.03	24.5 ±12.23	*0 - 25*
CK (IU/l)	161.5 ± 20.14*	165.8 ± 23.78*	143.5 ±22.47	247.7 ± 30.87*	176.3 ± 19.65*	54 ±14.65	*0 - 60*
GLDH (IU/l)	12.51 ±6.45*	9.575 ± 2.47	7.32 ±3.58	5.9 ±2.47	11.8 ± 7.21*	19.3 ± 8.21*	*0 - 7*
TP (g/l)	101.8 ± 9.85*	78.48 ±10.11	75.41 ±6.45	80.15 ± 9.84	88.28 ± 8.94*	102.1 ± 16.94*	*60 -.80*
Bili (mmol/l)	8.424 ±3.57	6.468 ±1.98	6.133 ±3.89	10.42 ± 4.21*	14.83 ±4.0*	7.65 ±3.05	*0.30 - 8.50*
Urea (mmol/l)	5.185 ±3.12	4.1 ±1.45	17.3 ± 6.47*	3.15 ±0.94	3.2 ±1.07	3.2 ±1.7	*0 - 8.0*

Concerning the blood clotting profile, the results showed that the recalcification, plasma thrombin, plasma thromboplastin and thromboplastogram reaction times were significantly ($p<0.01$) higher, Whereas, plasma fibrinogen was significantly ($p<0.01$) lower than the normal range (table 3).

Table 3: Blood clotting parameters.

The blood gases analysis revealed insignificant differences in all the examined parameters (table 4).

Table 4: Blood gases parameters.

The urine colour was light or darck yellow in 33.75%, light yellow or colourless in 28.75% or gold yellow in 35% of cows.The specific gravity was lower than 1.020 in all cows. The pH was lower than 7.0 degree in 27.71%, between 7.0 and 8.0 degree in 39.75% and more than 8.0 degree in 32.53%. The protein concentration was less than 15 mg / dl in 24.39%, between 15 and 20 mg / dl in 8.53%, 30 mg / dl in 47.56% and 100 mg / dl in 18.85% of cows. The ketone bodies concentration was lower than 15 mg / dl in 83.52%, 40 mg / dl in 4.71%, 80 mg / dl in 5.88% and 160 mg / dl or more in 4.71% of cows.The glucose concentration was less than 100 mg / dl in 91.76%. The bile pigments were abscent or only traces in 98.75%. The haemoglobin and red blood cells were abscent in 78.75%, 25 erythrocytes / µl in 8.75%, 80 erythrocytes /µl in 5% and 200 erythrocytes /µl in 7.50% of cows (table 5).

Table 5: Urine examinations.

The ruminal fluid colour was brownish green in 85.71% and grey olive in 14.28% of cows. The odour was aromatic in 95.77% and acidic in 4.22%. The ruminal fluid was viscous in 51.42% and watery in 47.14%. The pH values were between 6.2 and 7.2 degree in 47.82% and more than 7.2 in 52.17% of cows. The sedimentation and flotation activity was normal in 30%, abscent in 32.85% and abscent of flotation and rapide sedimentation in 37.14%. The methylene blue reduction time was shorter than 3 min. in 53.62%, longer than 3 min. in 36.23% and longer than 6 min. in 10.14% of cows. The infusoria was abundent in 22.85%, moderate in 38.57%, few in 22.85% and abscent in 15.71% of cows (table 6).

Table 6: Ruminal fluid examinations.

Discussion

The encountered metabolic disturbances associated with claw disorders in this study were: alkalosis, primary acetonaemia, hypocalcemia, hypophosphatemia, hypomagnesemia and fat cow syndrome.

In the present study, significant neutrophilia, increase in the levels of creatin kinase, glutamate dehydrogenase and total protein were associated with alkalosis. Significant eosinophilia and increase in the creatin kinase activity were associated with primary acetonemia. Leukocytosis, neutrophilia, decrease in haematocrit value, and increased urea level were associated with hypocalcemia. Significant increase in the creatin kinase and bilirubin values were found in hypophosphatemia. Neutrophilia, increased creatin kinase, glutamate dehydrogenase, total protein and bilirubin values were associated with hypomagnesemia. Neutrophilia, increased activity of glutamate dehydrogenase and level of total protein were associated with fat cow syndrome. Meanwhile, Nilsson (1963) found that in cows affected by acetonaemia associated with claw disorders, the erythrocytic and total leukocytic count, magnesium and sodium were insignificantly higher, whereas, the proportion of basophils, immature neutrophils, monocytes, calcium and phosphorus were significantly low. Similar findings were recorded by Maclean (1965 / 1966 / 1970) who found that in cows affected by claw disorders associated with acetonaemia the erythrocytic count, the total leukocytic count, proportion of basophils, immature neutrophils, monocytes and aspartate aminotransferase were within normal.

It has been suggested that hypocalcemia may cause adrenal cortical hyperactivity resulting in leukocytosis and neutrophilia. The increased bilirubin level in cases of hypophosphatemia indicate the presence of hepatopathy. Cows with fatty liver have increased blood concentration of liver-specific enzymes (Radostitis et al, 1994).

Acetonaemia is often associated with fatty infiltration of the liver or liver degeneration and this tissue damage might contribute a focus for increased histamine formation which predisposes to claw affections. The claw disorders and the associated acetonaemia may be due to abnormal ruminal bacterial fermentation which often occurs in connection with acetonaemia caused by a protein rich diet with unbalanced feeding. In this condition there are overgrowth of the physiological ruminal flora by bacteria of the coli and proteus strains which occur in alkaline pH and toxic products are formed (Nilsson, 1963 and Dirksen,1983).

Also, the fatty acids formed in case of chronic latent ruminal acidosis may be shifted in favor of the proportion of butyric acid which can transformed into beta-hydroxybtyric acid resulting in subclinical ketosis. Ruminal acidosis due to ration rich in easily digestible carbohydrates leads to many metabolic disorders such as metabolic acidosis, subclinical ketosis and fat cow syndrome. These metabolic changes can be considered in this respect as the primary factor in the pathogenesis of claw disorders. In case of claw disorders associated with ruminal acidosis, the toxic feed decomposition products absorbed from the rumen seem to cause severe circulatory disturbances in the claw corium with separation of the horny capsule from the third phalangeal bone (Dirksen, 1983). Meanwhile, Modrakowski (1978) found that metabolic and circulatory disturbances diminished blood supply and nutrition to claw corium leading to the manifestation of pododermatitis circumscripta.

The changes in the blood clotting profile indicate that there are marked microcircultory disturbances in the claw corium. Nilsson (1963) and Boosman (1990) found that activation of the clotting system resulted from endotoxaemia, reflected by thrombocytopenia, increased PT, PTT and circulating soluble fibrin monomers could possibly lead to blockage of the claw microcirculation leading to laminitis. This supports the findings of Hofmann (1992) who described that in all forms of laminitis there is microcirculatory disturbances in the claw corium which may be due to allergic agents, endotoxin (histamine, lactic acid), bacterial toxins, blood acidosis. All these factors lead to direct damage of the endothelial cells or diffuse intravascular clotting and both lead to disturbances in the permeability of the capillaries resulting in destruction of the connection between the claw horn and the claw corium.

Regarding the concentrations of blood gases insignificant differences in the average oxygen tension, hydrogen carbonate concentration in plasma and actual base excess have been encountered. On the other hand Boosman (1990) found significant difference in the actual base excess in laminitic cows. This result means that there was no marked variations in blood gases parameters in relation to claw disorders.

The urine analysis indicated the presence of proteinuria with alkaline pH whereas ketone bodies has been encountered. Apparently, there was no marked specific changes in the urine parameters in relation to claw disorders. The changes of the ruminal fluid were more or less within the physiological range.

In conclusion it can be said that, the occurrence of claw affections in association with metabolic disturbances may be attributed to the metabolic and circulatory changes associated with ruminal acidosis, acetonaemia, fatty liver, hypocalcemia, hypophosphatemia and hypomagnesemia. These metabolic changes lead to the production of histamine, ketone bodies and lactic acid which causing severe microcirculatory disturbances in the claw corium. The mirocirculatory disturbances leading to ischemic necrosis and degeneration of the horn producing structures and destruction of the connection between claw horn and corium predisposing to claw affections.

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