Research Article

Effects of Oxytetracycline and Flunixin Meglumine Treatments on the Haematological and Serum Biochemistry Profiles of Goats Experimentally Induced with *Mannheimia haemolytica* Pneumonia

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Abstract | Mannheimiosis is one of the common causes of pneumonia caused by *Mannheimia haemolytica.* Evaluation of the hematological and serum biochemistry changes is critical to determine the effectiveness of the treatment approach in reducing the severity of infection. Healthy goats (n=20) were equally divided into 5 groups: *Mannheimia haemolytica* 10^7 concentration was inoculated intranasally to all goats except goats of Group 1 which served as the negative control, Group 2 was the positive control, Group 3 goats treated with oxytetracycline, Group 4 goats were treated with flunixin meglumine, and group 5 received both oxytetracycline and flunixin meglumine treatments. Blood samples were collected at 24 hours, days 5, 7, 9, 11, 14, 21, and 28 post-inoculation for the clinical pathology evaluation through complete blood count and serum biochemistry evaluation. Results showed that post-infection resulted mild fluctuation of the red blood cell parameters in the goats with a decrease in the total white blood cell count ($p<0.05$). The serum biochemistry shows the total protein, albumin and globulin are within the range with mild increment in creatine kinase, blood urea nitrogen, and gamma glutaryl transferase however there were increased lactate dehydrogenase levels post-infection with *Mannheimia haemolytica* ($p<0.05$). In conclusion, oxytetracycline and flunixin meglumine treatments does not have a great influence on the parameters evaluated in goats experimentally induced with *Mannheimia haemolytica* pneumonia.

Keywords | Haematological, Biochemistry, Goats, Pneumonia, Mannheimiosis

Received | August 19 2022; **Accepted** | September 15, 2022; **Published** | February 15, 2023
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Citation | Hamid FFA, Reduan MFH, Sabri J, Abdullah FFJ, Odhah MN, Manaf NABA, Norsidin MJ, Yahya SNC, Kamaruzaman INA, Rajdi IM (2023). Effects of oxytetracycline and flunixin meglumine treatments on the haematological and serum biochemistry profiles of goats experimentally induced with *mannheimia haemolytica* pneumonia. J. Anim. Health Prod. 11(1): 73-81.
DOI | http://dx.doi.org/10.17582/journal.jahp/2023/11.1.73.81
ISSN | 2308-2801

INTRODUCTION

Pneumonia is a common respiratory condition in the tropical region and has been the major contributor to economic losses after diarrhea in small ruminant industries (Dohare et al., 2013). *Mannheimia* sp. is among the common causative agents contributing to the high prevalence of Mannheimiosis in small ruminants (Chung et al., 2015). These opportunistic pathogens produce diseases when the animal is immunocompromised (Rice et al., 2007). They often disrupt the innate mucosal defense mechanism and

lead to acute pulmonary infections characterized by a necrotizing inflammatory response (Sabri et al., 2013).

Haematological and serum biochemistry profiles are valuable diagnostic tools that are helpful in the diagnosis of many organs and systemic diseases supported by history and clinical examination findings. The information assists in diagnosis, surveillance and predicting the prognosis of the animal, planning of the therapeutic options and monitoring response to treatments (Russell and Roussel, 2007; Roland et al., 2014). In this study, oxytetracycline and flunixin meglumine drugs were used to evaluate the effectiveness of the treatment through haematology and serum biochemical changes in goats inoculated with mannheimiosis. Oxytetracycline is a broad spectrum antimicrobial drug commonly applied for gastrointestinal and respiratory tract diseases (Aktas & Yarsan, 2017). Meanwhile, flunixin meglumine is used to alleviate the inflammation response towards respiratory disease or endotoxemia (Weil & Baird, 2021). Until today, the hematological and serum biochemical findings in the post-treatment of mannheimiosis in goats are still lacking. This study aims to evaluate the hematological and serum biochemical changes upon inoculation and post-treatments of mannheimiosis.

MATERIAL AND METHODS

Animals and management

Twenty healthy goats were used in this study and the goats were kept in separate pens and fed with commercial goat pellets. They were provided with *ad libitum* of Napier grass and drinking water. The experimental procedure was conducted under the approval of the Animal Care and Use Ethics Committee (ACUC), Faculty of Veterinary Medicine, Universiti Malaysia Kelantan. The ethical approval number was (UMK/FPV/ACUC/PG/3/2021).

Bacteria preparation and experimental design

Mannheimia haemolytica growth on the blood agar plate was used as inoculum. The infection dose of the bacteria inoculum was standardized at 10^7 CFU/ml concentration using 10^7 McFarland's standard. Twenty goats were equally divided into five groups (Groups 1, 2, 3, 4 and 5). Group 1 was kept as a negative control and given 1 mL of sterile phosphate-buffered saline (PBS) intranasally and all other groups were inoculated with 10^7 CFU/1mL of *Mannheimia haemolytica* intranasally. Goats in the Group 2 were kept as the positive control and no treatment was given in the study period while goats in Group 3 were treated with antimicrobial (Oxytetracycline, 20 mg/kg, SID) on days 6 and 9 post-infection. Group 4 was treated only with an anti-inflammatory drug (Flunixin meglumine, 1.1mg/kg, BID) for 5 days of post-infection and Group 5 received both antimicrobial (Oxytetracycline, 20 mg/kg, SID) on days 6 and 9 and anti-inflammatory drug (Flunixin meglumine, 1.1 mg/kg, BID) treatment for five days on post-infection. Blood samples were collected via jugular vein at 24 hours, days 5, 7, 9, 11, 14, 21, and 28 days post-infection for the analysis.

Laboratory analyses

Blood samples were analysed using an automatic haematology analyser (Scil Vet abc™, Horiba Medical, Montpellier, France) for the red blood cell (RBC) count, haemoglobin concentration (Hb), hematocrit (HCT), mean corpuscular volume (MCV) and mean corpuscular haemoglobin concentration (MCHC), platelets (PLT), total number of white blood cells (WBC).

An automatic biochemistry analyser (Randox, RX daytona, United Kingdom) was used to determine the concentrations of total protein (TP), albumin (ALB) and globulin (GLOB), blood urea nitrogen (BUN), creatine kinase (CK), gamma-glutamyl transferase (GGT) and lactate dehydrogenase (LDH).

Statistical analysis

The data was analysed using Statistical Package for Social Science (SPSS) software version 26. The values were expressed as mean ± standard deviation (SD) for different parameters. Analysis of variance (ANOVA) tests were done to compare the differences of data between and within groups. Post hoc analysis using Duncan test were used to determine the level of statistical significance which was set at $p<0.05$.

RESULTS

For the haematological evaluation, within 24 hours of post- inoculation, RBC counts show there was significant ($p<0.05$) reduction of the RBC levels in all groups compared to the negative control. Levels of the Hb demonstrated no significant difference observed in all groups. The HCT levels showed a significant ($p<0.05$) decrease in all inoculated groups compared to negative control groups at 24 hours to day 9 of post-inoculation (Table 1). The MCV shows a significant ($p<0.05$) increase in the levels in all group compared to negative control. Meanwhile, MCHC shows a significant increase ($p<0.05$) in both groups 2 and 5 compared to negative control (Table 2).

On day 5 of post- inoculation which is the peak of infection, RBC evaluation revealed there was a significant ($p<0.05$) reduction in RBC level in all groups compared to the negative control. The Hb concentration in group 3 was significantly ($p<0.05$) decreased compared to the negative control. HCT levels show a significant decrease ($p<0.05$) in all groups compared to group 1 (negative control)

Table 1: Red Blood cells parameters (mean ± SD) of goats experimentally infected with Mannheimiosis

Groups	24 hr	Day 5	Day 7	Day 9	Day 11	Day 14	Day 21	Day 28
Red Blood Cells (RBC) (x10^6 µl)								
Group 1	20.97±2.08^c	20.97±2.08^d	21.04±2.15^b	21.05±2.15^c	21.05±2.15^c	20.97±2.08^c	20.97±2.08^b	20.97±2.08^b
Group 2	11.59±1.27^a	12.17±1.70^a	13.15±3.06^a	11.38±1.08^a	12.18±2.69^a	13.29±2.07^a	14.15±2.26^a	14.06±2.69^a
Group 3	12.95±1.29^a	13.87±1.75^{ab}	15.50±3.59^a	16.16±3.37^b	15.27±2.40^{ab}	16.67±2.62^{ab}	16.24±1.89^a	17.30±2.39^{ab}
Group 4	14.75±0.95^b	18.25±1.06^c	19.16±1.03^b	18.80±1.41^{bc}	17.23±0.84^b	18.66±0.08^{bc}	19.43±1.31^b	19.72±3.64^b
Group 5	13.31±1.03^{ab}	15.40±1.08^b	15.10±1.13^a	15.68±1.15^b	14.46±1.43^{ab}	15.32±2.75^{ab}	15.95±1.56^a	16.97±0.46^{ab}
Hemoglobin (HGB) (g/dl)								
Group 1	9.30±0.87^a	9.30±0.87^b	9.35±0.88^b	9.35±0.88^b	9.35±0.88^b	9.30±0.87^a	9.30±0.87^b	9.30±0.87^b
Group 2	7.47±0.97^a	5.75±1.93^{ab}	7.05±0.70^{ab}	6.30±0.71^{ab}	6.40±0.67^a	7.12±0.25^a	7.02±0.40^{ab}	7.42± 0.17^a
Group 3	5.37±1.33^a	4.78±3.26^a	7.40±1.22^{ab}	7.67±1.20^{ab}	7.07±0.94^{ab}	8.02±0.99^a	7.20±0.48^{ab}	7.87± 0.21^a
Group 4	9.16±0.90^a	7.83±0.34^{ab}	7.86±0.47^a	7.90±0.71^a	7.03±0.38^a	7.17±0.75^a	7.70± 0.50^a	7.83 ±1.66^a
Group 5	7.02±2.79^a	7.65±0.67^{ab}	7.50±0.77^{ab}	7.67±0.68^{ab}	7.05±0.39^{ab}	7.65±1.68^a	7.32±0.85^{ab}	8.90± 1.67^a
Haematocrit (HCT) (%)								
Group 1	35.55± 3.87^b	35.55± 3.87^b	35.55±3.87^b	35.55±3.88^b	35.55±3.88^d	35.55±3.87^a	35.55 ±3.87^a	35.55±3.87^{ab}
Group 2	23.26±0.40^a	23.48±0.38^a	21.33±2.21^a	20.88±1.67^a	19.22±1.41^b	22.97±3.74^a	24.75±2.30^a	26.97± 1.06^{ab}
Group 3	22.46±1.03^a	22.46±1.03^a	21.07±1.10^a	20.67±1.79^a	25.57±4.16^c	28.86±2.34^a	25.95±2.21^a	28.02±1.72^{ab}
Group 4	21.97±1.12^a	21.97±1.12^{ab}	27.68±1.43^a	27.68±1.43^a	27.68±1.43^a	32.10±2.62^a	32.70±2.29^a	33.55±2.72^{ab}
Group 5	23.05±0.54^a	23.05±0.54^a	27.42±1.18^a	27.42±1.18^a	26.45±1.17^c	29.75±0.52^a	30.52±1.20^a	31.10± 1.68^a

Note: Different superscript letters on the group means in each column indicate significant difference (p< 0.05).

Table 2: Mean hemoglobin concentration and mean corpuscular volume (mean± SD) in goats experimentally infected with Mannheimiosis

Groups	24 Hr	Day 5	Day 7	Day 9	Day 11	Day 14	Day 21	Day 28
Mean hemoglobin concentration (MCHC) (g/dl)								
Group 1	40.10± 26.54^a	40.10±26.54^a	26.35±1.08^a	26.35±1.08^a	26.35±1.08^a	40.10±26.54^{ab}	40.10±26.54^{ab}	40.10± 26.54^{ab}
Group 2	97.05± 8.85^{bc}	65.27±36.98^a	58.07±36.82^a	58.60±24.21^{ab}	47.17±16.09^a	36.05±8.14^{ab}	39.67±23.58^{ab}	46.67± 38.89^{ab}
Group 3	99.05± 25.08^{bc}	56.32±48.27^a	73.02±25.66^a	45.12±33.70^a	27.95±3.94^a	52.30±30.25^b	42.42±29.34^b	31.25± 21.19^b
Group 4	60.77± 40.62^{ab}	42.52±52.74^a	45.10±41.63^a	88.40±58.60^{ab}	44.02±30.86^a	15.50±10.70^a	17.72± 11.81^a	16.85± 12.48^a
Group 5	110.25± 14.44^c	91.90±43.40^a	66.27±43.98^a	123.70±64.54^b	29.65±1.68^a	16.87±19.93^a	45.62±15.11^b	49.72± 8.02^b
Mean corpuscular volume (MCV) (fl)								
Group 1	17.91± 1.96^a	17.88±1.98^a	17.91±1.96^a	17.88±1.98^a	17.91±1.96^a	17.88±1.98^a	17.88±1.98^a	17.91± 1.96^a
Group 2	34.25± 0.96^b	34.48± 2.68^c	30.37±5.40^b	33.75±0.50^b	30.45±4.37^b	26.51±6.15^{ab}	17.66± 2.45^a	33.84± 2.31^c
Group 3	33.50± 1.29^b	33.25±0.95^{bc}	32.91±2.31^b	32.91±2.32^b	16.70±0.34^a	32.29±2.13^b	17.56±1.92^a	25.30± 10.07^b
Group 4	33.33± 0.47^b	29.35± 5.31^b	27.53±7.73^b	33.33±0.47^b	32.33±0.94^b	23.25±8.56^{ab}	16.66± 0.09^a	31.55± 2.63^{bc}
Group 5	33.25± 0.50^b	32.28±2.29^{bc}	29.80±4.37^b	29.70±8.60^b	16.47±0.15^a	25.83±6.80^{ab}	32.60± 2.33^b	34.25± 0.50^c

Note: Different superscript letters on the group means in each column indicate significant difference (p< 0.05).

Table 3: Total White blood cell count and platelet evaluation (mean± SD) in goats experimentally infected with Mannheimiosis

Groups	24Hr	Day 5	Day 7	Day 9	Day 11	Day 14	Day 21	Day 28
				Total White Blood cell count (cells/µl)				
Group 1	31.65± 2.61[b]	31.65± 2.61[a]	26.60± 10.46[a]	26.60± 10.46[a]	26.60± 10.46[a]	26.77± 10.13[a]	26.77± 10.13[a]	52.47± 41.70[b]
Group 2	13.30± 4.90[a]	15.97± 7.47[a]	19.52± 9.44[a]	13.30± 2.45[a]	15.40± 3.82[a]	19.05± 2.20[a]	12.27± 8.37[a]	17.20± 1.26[a]
Group 3	9.17± 3.63[a]	13.07± 17.82[a]	19.25± 10.94[a]	18.65± 8.05[a]	17.60± 8.05[a]	16.85± 6.62[a]	13.60± 10.91[a]	29.30± 27.68[a]
Group 4	10.1± 7.82[a]	9.025± 26.19[a]	10.52± 7.29[a]	8.45± 6.0.5[a]	9.00± 6.29[a]	9.67± 7.19[a]	11.00± 8.17[a]	9.50± 6.59[a]
Group 5	8.85± 4.55[a]	11.97± 2.27[a]	13.75± 3.78[a]	13.90± 2.445[a]	14.52± 4.77[a]	14.65± 4.01[a]	15.55± 4.39[a]	24.72± 18.90[a]
				Platelet (x10^3 µl)				
Group 1	259.25± 62.55[a]	259.25± 62.55[a]	267.00± 54.50[a]	267.00± 54.49[a]	267.00± 54.49[a]	259.25± 62.55[a]	259.25± 62.55[a]	259.25± 62.55[a]
Group 2	267.00± 54.50[a]	320.75± 261.67[a]	397.25± 265.63[a]	406.50± 270.91[a]	409.25± 270.91[a]	433.25± 282.52[a]	435.00± 239.01[a]	344.25± 215.00[a]
Group 3	259.25± 62.55[a]	137.25± 111.19[a]	414.25± 205.31[a]	397.50± 203.68[a]	399.25± 226.44[a]	459.25± 265.21[a]	405.00± 279.00[a]	340± 201.51[a]
Group 4	267.00± 54.50[a]	331.00± 290.11[a]	278.00± 249.44[a]	328.75± 266.98[a]	260.00± 218.29[a]	327.25± 220.83[a]	257.25± 227.93[a]	381.25± 402.22[a]
Group 5	267.00± 54.550[a]	307.00± 159.95[a]	282.00± 116.73[a]	287.00± 140.80[a]	238.75± 23.71[a]	538.50± 387.05[a]	259.75± 91.16[a]	303.75± 273.15[a]

Note: Different superscript letters on the group means in each column indicate significant difference ($p < 0.05$).

Table 4: Total proteins, albumin and globulin (mean± SD) level in blood of goats experimentally infected with Mannheimiosis

Groups	24Hr	Day 5	Day 7	Day 9	Day 11	Day 14	Day 21	Day 28
				Total protein (TP) (g/dl)				
Group 1	6.67 ± 0.68 [b]	6.70± 0.53[a]	6.67± 0.53[a]	6.70± 0.53[ab]	6.67±0.68[a]	6.70± 0.53[a]	6.67±0.68[a]	6.70±0.53[a]
Group 2	6.38 ± 0.52 [a]	6.57 ±0.50[a]	6.23±0.14 [a]	6.32±0.37 [a]	7.37 ± 0.60 [ab]	7.42± 0.50 [ab]	7.25 ±0.27[b]	7.18 ± 0.11[b]
Group 3	5.90±0.54[ab]	7.37±0.64[a]	6.40±0.48[a]	7.25 ± 0.54[b]	7.67±0.43[b]	7.72± 0.54[b]	7.82 ± 0.51[b]	7.93±0.50[b]
Group 4	4.32 ±2.90[a]	4.92 ±3.40[a]	6.27±0.05[a]	6.65±0.63[ab]	7.62±0.42[b]	7.57± 0.57[ab]	7.83±0.41[b]	7.92±0.40[b]
Group 5	6.61±0.31[b]	6.80 ±0.14[a]	6.70 ±0.08[a]	6.87±0.40[ab]	6.87±0.55[ab]	6.90± 0.57[ab]	7.55±0.24[b]	7.65 ±0.27[b]
				Albumin (ALB) (g/dl)				
Group 1	3.27 ± 0.30[b]	3.27 ± 0.30[a]	3.12 ±0.31[ab]	3.27 ± 0.31[a]	3.12 ± 0.31[a]	3.27 ± 0.30 [b]	3.27 ± 0.30 [a]	3.12 ± 0.31[b]
Group 2	3.17 ± 0.21[b]	3.02 ±0.27[a]	3.30 ±0.14[b]	3.33 ± 0.21[a]	3.62 ± 0.12[b]	3.58 ± 0.10 [a]	3.62 ± 0.08[a]	3.57 ± 0.05[a]
Group 3	3.12 ±0.10[b]	3.37 ± 0.25[a]	3.17 ± 0.12[ab]	3.57 ± 0.22[a]	3.62 ± 0.41[b]	3.65 ± 0.24 [a]	3.67 ± 0.19 [a]	3.64 ±0.17 [b]
Group 4	2.08 ±1.39[a]	2.42± 1.63[a]	2.95 ± 0.21[a]	3.30 ±0.14[a]	3.52 ± 0.12[b]	3.55 ± 0.24 [a]	3.68 ± 0.20[a]	3.58 ± 0.09 [a]
Group 5	3.09 ±0.17[b]	3.50 ± 0.33 [a]	3.17 ±0.19[ab]	3.65 ±0.19[a]	3.60 ±0.21[b]	3.70 ± 0.20 [a]	3.71 ±0.14 [a]	3.71 ±0.06 [a]

				Globulin (g/dl)				
Group 1	3.40± 0.41[a]	3.42 ± 0.62[a]	3.55 ± 0.96[a]	3.42 ± 0.62[a]	3.55 ± 0.96[a]	3.42 ± 0.62[a]	3.40 ±0.82[a]	3.57 ± 0.64[a]
Group 2	3.20 ±0.62[a]	3.55 ±0.26[a]	2.93±0.25[a]	3.80 ± 1.44[a]	3.75 ± 0.62[a]	3.84 ± 0.55[a]	3.63 ± 0.30[a]	3.60 ± 0.12[a]
Group 3	2.77 ± 0.56[a]	4.00 ± 0.50[a]	3.22 ± 0.50[a]	3.67 ± 0.35[a]	4.05 ± 0.42[a]	4.06 ± 0.40[a]	4.14 ± 0.42[a]	4.29 ±0.55[ab]
Group 4	2.24 ± 1.53[a]	2.50 ± 1.95[a]	3.32 ± 0.25 [a]	3.35 ± 0.75[a]	4.10 ± 0.32[a]	4.02 ± 0.66[a]	4.15 ± 0.53[a]	4.34 ± 0.47[b]
Group 5	3.52 ± 0.44[a]	3.30 ± 0.43[a]	3.52 ±0.25 [a]	3.22 ± 0.46[a]	3.27 ± 0.55[a]	3.20 ± 0.39[a]	3.84 ± 0.13[a]	3.94 ±0.21[ab]

Note: Different superscript letters on the group means in each column indicate significant difference (p< 0.05).

Table 5: Blood urea nitrogen and Creatine Kinase (mean± SD) level in goats experimentally infected with Mannheimiosis

Groups	24Hr	Day 5	Day 7	Day 9	Day 11	Day 14	Day 21	Day 28
				Blood Urea Nitrogen (BUN) (mg/dl)				
Group 1	12.50 ± 0.82[a]	12.50 ± 0.82[a]	12.32 ± 0.87[a]	12.32 ± 0.87[a]	12.32 ± 0.87[a]	12.50 ±0.81[a]	12.50 ± 0.81[a]	12.32 ± 0.87[a]
Group 2	15.82 ± 0.36[b]	18.95 ± 0.99[b]	21.25 ± 0.51[bc]	19.50 ± 1.33[bc]	19.32 ± 1.67[b]	19.40 ± 0.77 [b]	18.77 ±0.55[b]	18. 40± 1.29[b]
Group 3	15. 72± 0.50[b]	19.29± 0.96[b]	20.35 ± 1.52[b]	17.55 ± 1.82[b]	25.37 ± 2.30[c]	26.55 ± 1.12[c]	25.47 ± 1.05[d]	26.55± 1.12[c]
Group 4	16.00 ± 0.38[b]	19.15 ±1.32[b]	22.27 ± 0.29[c]	20.50 ± 1.58[c]	30.52 ± 1.90[d]	26.60 ± 2.30[c]	26.70 ± 1.60[d]	26.57± 1.58[c]
Group 5	16.30 ±0.60[b]	19.92 ± 1.65[b]	21.87 ± 0.88[c]	19.07 ± 0.86[bc]	20.35 ±1.45[b]	20.50 ± 0.67 [b]	21.62± 0.75[c]	24.37±2.50[c]
				Creatine Kinase (CK) (U/L)				
Group 1	55.75 ± 11.89[a]	59.00 ± 10.86[a]	55.75± 11.89 [a]	55.75 ± 11.89[a]	59.00 ± 10.86[a]	55.75 ± 11.89[a]	59.00 ± 10.86[a]	55.75 ± 11.89[a]
Group 2	59.30 ± 1.68[ab]	78.12 ± 4.51[cd]	85.30 ± 1.59 [d]	83.02 ± 15.32[b]	106.75 ± 12.30[b]	98.97 ± 12.03[bc]	94.17 ± 3.58[b]	95.55 ± 5.28[b]
Group 3	67.27 ± 3.67[bc]	72. 25 ± 0.71[bc]	70.60 ± 1.40 [b]	82.22 ± 6.32[b]	126. 45 ± 12.28[c]	114.17 ± 16.09[cd]	111.65 ±12.93[cd]	121.22 ± 13.15[c]
Group 4	69. 85 ± 2.42[c]	64. 35 ± 4.79[ab]	74.55 ± 1.96[bc]	82. 50 ± 11.48[b]	131.90 ±4.66[c]	123.75 ± 4.49[d]	122.17 ± 5.22[d]	122.37 ± 3.83[c]
Group 5	62.12 ± 2.37 [abc]	86.77 ± 6.12[d]	80.00 ± 1.36[cd]	90.00 ±9.61[b]	94.90 ± 4.38[b]	94. 45 ±4.68[b]	104. 02 ± 1.26[bc]	107.20 ± 5.78[b]

Note: Different superscript letters on the group means in each column indicate significant difference (p< 0.05).

(Table 1). The MCV shows a significant increase (p<0.05) in all groups except for the negative control. The MCHC showed no significant differences (p>0.05) between groups were evidenced (Table 2).

On days 9 , 14 , 21 and 28 of the post-inoculation (post-treatment), significant decrease of RBC levels were observed in group 2 (positive control) in comparison to group 1 (negative control) and group 4 on day 28. The Hb concentrations at days 9 were significantly decreased (p<0.05) in group 4 compared to the negative control. On day 28 of post-inoculation, the Hb levels declined significantly (p<0.05) in all inoculated groups compared to the negative control (Table 1). On day 14 of post-inoculation, the MCV values in group 3 demonstrated a significant (p<0.05) increase compared to the negative control. On day 21, the levels of MCV in group 5 remained significantly (p<0.05) increased compared to all other groups. On day 28 post-inoculation, all inoculated groups had significantly (p<0.05) higher levels of MCV compared to the negative control. However, the values in group 3 were significantly (p<0.05) lower compared to groups 2 and 5. The MCHC level shows there was significant increase (p<0.05) in group 5 at day 9 in comparison to the negative control and group 3. On day 14, there was a significant (p<0.05) reduction in MCHC levels in groups 4 and 5 compared to the negative control and groups 2 and 3. On days 21 and 28, goats in group 4 demonstrated significantly (p<0.05) reduced levels

Table 6: Gamma Glutaryl Transferase and Lactate Dehydrogenase (mean± SD) level of goats blood experimentally infected with Mannheimiosis

Groups	24Hr	Day 5	Day 7	Day 9	Day 11	Day 14	Day 21	Day 28
Gamma Glutaryl Transferase (GGT) (U/L)								
Group 1	78.50 ± 7. 14^{c}	70.75 ± 1.70^{a}	78.5 ± 7.14^{c}	70.75 ± 1.70^{a}	78.50 ± 7.14^{a}	70.75 ± 1.70^{a}	78.50 ± 7.14^{a}	70.75 ± 1.70^{a}
Group 2	61.92 ± 2.08^{ab}	69.87 ±8.09^{a}	63.35 ±2.16^{b}	88.25 ± 7.58 ^{b}	103. 82 ± 10.68^{b}	97.00 ± 3.98 ^{b}	96.80 ± 2.33^{b}	97.22 ± 2.18^{b}
Group 3	62.62 ± 3.75^{b}	70. 67 ± 7.20^{a}	64.87 ± 3.28^{b}	80.92 ±7.61 ^{b}	107.70 ± 8.32^{b}	109.70 ± 4.73^{c}	106.25 ± 6.16^{c}	104. 80 ± 3.16^{c}
Group 4	62.02 ± 3.64^{ab}	65. 37 ± 4.38^{a}	61. 57± 3.90^{b}	88. 72 ± 6.92^{b}	119.02 ± 5.42^{c}	117.57 ± 4.97^{d}	119.17 ±2.10^{d}	117.02 ± 1.54^{d}
Group 5	55.57 ± 2.83^{a}	99.12 ± 4.34^{b}	54.52 ± 0.62^{a}	99. 85 ± 6.42^{c}	100. 37 ± 3.02^{b}	102.55 ± 3.31^{b}	104. 20 ± 1.62^{c}	104.52 ± 2.12^{c}
Lactate Dehydrogenase (LDH) (U/L)								
Group 1	512. 25 ± 73.21^{a}	528.25 ± 58.11^{a}	512.25 ±73.21^{a}	528. 25 ± 58.11^{a}	512.25 ±73.21^{a}	528.25 ± 58.11^{a}	512.25 ± 73.21^{a}	528.25 ± 58.11^{a}
Group 2	1198.75 ±31.61^{b}	1008.75 ± 18. 46^{b}	1129.25 ± 80.03^{b}	1033. 75 ± 58.02^{b}	1105.25 ± 116.36^{b}	1098.00 ± 113.26^{b}	1098.00± 113.26^{b}	1063.75 ± 63.88^{b}
Group 3	1240.75 ± 66.43^{bc}	1170.25 ± 52.82^{cd}	1169.75 ± 92.86^{b}	1162.25 ± 44.97^{c}	1137.75 ± 18.50^{b}	1105.25 ± 62.88^{b}	1105.25 ± 62.88^{b}	1072.50 ± 62.38^{b}
Group 4	1295.25 ± 39.20^{cd}	1075.00 ± 86.26^{bc}	1205.50 ± 67.48^{b}	1124.25 ± 92.65^{bc}	1116.50 ± 86.84^{b}	1092.50 ± 107.46^{b}	1092.50 ± 107.46^{b}	1133.75 ± 122.91^{b}
Group 5	1343.50 ± 31.20^{d}	1225.50 ± 144.15^{d}	1316.25 ±40.59^{c}	1299.25 ± 54.18^{d}	1290.25 ±49.88^{c}	1296.00 ±54.37^{c}	1296.00 ± 54.37^{c}	1267.00 ± 88.97^{c}

Note: Different superscript letters on the group means in each column indicate significant difference ($p< 0.05$).

of MCHC compared to the negative control and groups 2, 3 and 5 (Table 2). No significant changes in the PLT value throughout the 28 days of study were recorded and those were within the normal range. Significantly decreased ($p<0.05$) total WBC count parameters in all groups except the negative control within 24 hours and on day 28 of post-inoculation was found (Table 3).

Serum biochemistry results of the TP evaluation revealed a significant ($p<0.05$) decreased in group 4 compared to negative control and group 5 at 24 hours of infection. On day 9, there was a significant ($p<0.05$) increase in TP levels in group 3 compared to positive control. On day 14, goats in group 3 showed a higher level ($p<0.05$) of the TP compared to negative control. On days 21 and 28 of post-inoculation, all inoculated groups remained significantly ($p<0.05$) higher in TP values than the negative control (Table 4).

Results on the BUN showed significant ($p<0.05$) increase in the levels of BUN in all inoculated groups compared to negative control at 24 hours and day 5 of post inoculation. On day 9 post-inoculation, all inoculated groups had high BUN levels ($p<0.05$) compared to negative control. On days 11 to 28, all inoculated groups also had significant ($p<0.05$) increase of BUN levels compared to the negative control group. On days 14 and 21, groups 3 and 4 showed significantly ($p<0.05$) higher levels of BUN compared to positive control and group 5. On day 28, group 2 has significantly ($p<0.05$) lower BUN level compared to all treatment groups. However, the value was slightly above the normal range after 9 days of infection (Table 5).

The CK values showed a significant ($p<0.05$) increase in groups 3 and 4 compared to negative control groups at 24 hours of post-inoculation. On day 5, the CK levels of groups 2, 3 and 5 were significantly ($p<0.05$) higher than negative control. On day 9, all of the inoculated groups demonstrated a significant ($p<0.05$) increase in the levels of CK compared to the negative control. Days 11 to 28 showed significantly ($p<0.05$) higher CK values than the negative control. Groups 3 and 4 had significantly ($p<0.05$) higher CK levels compared to positive control and treatment group 5 on days 11 and 28. Meanwhile, group 5 had significantly ($p<0.05$) lower CK levels compared to groups 3 and 4 on day 14 and significantly ($p<0.05$) lower CK levels compared to group 4 on day 21. However, the values were within the normal range (Table 5).

GGT levels were observed to be decreased in all inoculated groups at 24 hours post-inoculation. On day 5, the GGT levels in group 5 significantly ($p<0.05$) increased compared

to all other groups. On days 9 to 28, all inoculated groups had significantly ($p<0.05$) higher levels of GGT compared to negative control. Group 4 were significantly ($p<0.05$) increased compared to groups 2, 3 and 5; and group 3 significantly ($p<0.05$) higher compared to groups 2 and 5 on day 14. Group 4 has a significantly ($p<0.05$) higher levels of GGT compared to positive control and treatment groups 3 and 5 on days 21 and 28 (Table 6).

Level of LDH ($p<0.05$) were observed higher in all inoculated groups from 24 hours until day 28 as compared to the negative control. Among groups, goats in group 5 were significantly ($p<0.05$) increased in LDH values compared to the positive control group from 24 hours to day 28 of experimental study. Meanwhile, group 3 has significantly ($p<0.05$) higher level of LDH than the positive control on days 9 and 11 (Table 6).

DISCUSSION

Haematological evaluations contribute information to the diagnosis, surveillance and prediction of the animal's prognosis (Roland et al., 2014). The variations in the haematological parameters observed in this study indicated that level of red blood cells and haemoglobin were reduced slightly post-infection. A similar pattern of clinicopathological alterations in the blood of sheep and lambs with pneumonia has shown to have lower haemoglobin concentration (Abdalla et al., 2019). Post-infection with *Mannheimia haemolytica* does reduce the level of haemoglobin in the blood. This reduction of haemoglobin results from the infection through the release of gram-negative endotoxin (LPS), which cause hemolysis and free release of haemoglobin (Brauckmann et al., 2016).

Decreasing patterns of haematocrit were observed in all groups at 24 h to day 11 post-infections. A previous study on caprine mycoplasma pneumonia and Pasteurellosis showed a significantly lower hematocrit level (Mondal et al., 2004). Post-infection increases MCV levels in the goats. The levels of MCV reduced and fluctuated throughout the studies in all groups. MCHC levels were slightly increased post-infection, but a pattern of reduction in the MCHC levels was observed on day 11. There was no noticeable treatment effect on MCHC values. A previous study by Saleh and Allam (2014) revealed a significant increase ($p<0.05$) in the MCV and MCHC values in the pneumonic ewes. Therefore these shows that the treatment does not cause a significant changes to the levels of red blood cells, haemoglobin and haematocrit levels post treatments in goats infected with Mannheimiosis.

Evaluation of total WBC count revealed leukopenia occurred in the goats, which demonstrated the recruitment and mobilisation of white blood cells from the blood to the injury site to combat the infection. These findings contrast with other studies which found that goats affected with common bacteria causing pneumonia, such as *Klebsiella pneumoniae, Pasteurella* spp., *Mannheimia* spp., which had an increase in the leucocytic count (Ghanem et al., 2015; Kattimani et al., 2020). Duration and chronicity of the infection also play a role in the recruitment and distribution of the white blood cells, which may cause a decrease in the leucocyte count, as observed in this study. In this study, it shows that treatments do not have a significant effects on the improvement of the white blood cell counts. This could be due to the length of the treatment given to the goats were insufficient in effectively normalize the levels of white blood cells counts in the goat post infections.

The serum biochemistry parameters in the recent study showed that the total protein, albumin and globulin values were within the normal range. Meanwhile, the levels of blood BUN showed a mild increment in post-infection, which was associated with dehydration and injury of the kidney. CK and GGT values were normal in all groups, but their levels had mild increases, which indicates liver injury. The study indicates the following serum biochemistry parameters does not shows a significant reduction nor improvement post-treatment regimes. This could be due to the dose of *Mannheimia haemolytica* infection in the goats were mild to moderate only.

In contrast to that, a significant increase in LDH was observed post-infection. In relation to respiratory diseases, LDH play role as one of the important indicator which can be used in monitoring the pathological changes related to the lung (Hagadorn et al., 1971). Lactate dehydrogenase is one of the indicators of lung damage as lungs have 500-fold higher LDH compared to their normal concentration in serum. Previous studies demonstrated an increase in the activity of LDH enzymes, particularly (LDH_4 and LDH_5) in lambs with lung lesions of acute and chronic pneumonia (Milne & Doxey, 1984; Drent et al., 1996; Klein et al., 2020). As observed in this study, Mannheimiosis causes alteration in the serum LDH level leading to their elevation which shows that it is due to the pneumonia development in the goats and the cellular injury that takes place in the lungs. This increment is due to the release of LDH from the epithelial cell of the airways lining that gives indicator of cell damage in the lungs (Drent et al., 1996) and the treatment regime does not significantly reduce the LDH level in the experimental goats. This also shows that the duration of treatment and the progression of disease does interferes with the level of LDH in the study and a longer length of treatment regimes may significantly improved or normalize better the level of LDH post treatment.

CONCLUSION

The haematological findings in goats experimentally induced with *Mannheimia haemolytica* demonstrated that post-infection causes a mild reduction in the red blood cell parameters (RBC, Hb, HCT) while decreased the total WBC count. The serum biochemistry findings were found within normal range for TP, ALB and GLOB, with mild to moderate increase in CK, BUN, GGT and LDH level. In conclusion, treatment does not have a great influence on the parameters evaluated except temporary lowering the values of some parameters.

ACKNOWLEDGEMENT

The authors would like to acknowledge the Ministry of Higher Education, Malaysia, for providing the FRGS-RACER grant (R/FRGS/A0600/01391A/001/2019/00668). The author would like to thank Madam Nur Eizzati Badrul Hisham and Miss Nani Izreen Mohd Sani from the Faculty of Veterinary Medicine, Universiti Malaysia Kelantan, for their technical assistance while conducting the research.

CONFLICT OF INTEREST

The author declared no conflict of interest.

NOVELTY STATEMENT

Treatment does not have a great influence on the parameters evaluated except temporary lowering the values of some parameters.

AUTHORS CONTRIBUTION

All author contributed equally to the research work and manuscript.

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