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Natural infections by small lungworms depress the respiratory function of goats

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الإصابة بطفيليات الرئة تضعف الوظيفة التنفسية عند الماعز

تمت دراسة التبديل الغازي الرئوي عند 6 ماعز مصاب بطفيليات الرئة مقارنة مع 8 ماعز سليمة من هذه الإصابة. وثيرة التنفس كانت مرتفعة عند الماعز المصاب بالطفيلية مقارنة مع الغير المصاب (41±11 مقابل 16±4). الضغط الجزئي لغاز الثاني أوكسيد الكربون (PCO_2)، البيكربونات (HCO_3^-) والكمية الإجمالية لغاز ثاني أوكسيد الكربون (CO_2) كانت مرتفعة عند الماعز المصاب مقارنة مع الماعز السليم من الإصابة (76,97 *vs* 39,85 mmHg ; 35,05 *vs* 21,59 mmol/l ; 41,13 *vs* 23,78 mmol/l) أما قيمة pH (7,18 مقابل 7,40) و الضغط الجزئي لغاز الأوكسجين PO_2 (39,95 *vs* 82,33mmHg) قد انخفضت مقاييسها عند الماعز المصاب مقارنة مع السليم. لوحظ تحسن مهم في أرقام التبديل الغازي الرئوي عن الماعز المصاب بطفيليات الرئة بعد معالجته بمادة الفنبندازول يستخلص من هذه الدراسة أن طفيليات الرئة تضعف الجهاز التنفسي عند الماشية المصابة.

الكلمات المفتاحية : الوظيفة التنفسية – الغازات الدموية – ديدان الرئة – الماعز

L'infestation naturelle par les petits strongles respiratoires altère la ventillation pulmonaire des chèvres

L'échange pulmonaire gazeux a été étudié chez 6 chèvres infestées par les petits strongles respiratoires et 8 autres indemnes. La fréquence respiratoire a été élevée chez les animaux infestés par rapport aux témoins (41±11 *vs* 16±4). La pression partielle du gaz carbonique (PCO_2), les bicarbonates HCO_3^- et la quantité totale de CO_2 ont été élevées (76,97 *vs* 39,85 mmHg ; 35,05 *vs* 21,59 mmol/l; 41,13 *vs* 23,78 mmol/l) chez les chèvres infestées par rapport à celles indemnes de parasites; alors que la valeur du pH (7.18 *vs* 7.40) et la pression partielle de l'oxygène des chèvres infestées (39.95 *vs* 82.33 mmHg) ont chuté. L'échange pulmonaire gazeux des chèvres infestées s'est normalisé après traitement par le fenbendazole à la dose de 15 mg/kg P.V. Il a été conclu que l'infestation des chèvres par les petits strongles altère leur fonction respiratoire.

Mots clés : Respiration - Pression partielle des gaz sanguins - Petits strongles - Chèvre

Natural infections by small lungworms depress the respiratory function of goats

Pulmonary gas exchange was studied in two groups of goats: group 1 (8 goats) acted as uninfected controls and group 2 (6 goats) were infected with small lungworms nematodes. The respiratory rate was higher in infected (41±11 Breaths/min) than in uninfected goats (16±4). The partial carbon dioxide arterial tension (PCO_2), total CO_2 and HCO_3^- were higher (respectively 76.97 *vs* 39.85 mmHg, 41.13 *vs* 23.78 mmol/l and 35.05 *vs* 221.59 mmol/l) in infected compared with uninfected goats, wheras arterial pH (7.18 *vs* 7.40) and partial tension oxygen PO_2 were lower (39.95 *vs* 82.33 mmHg) in infected goats. The blood gas and breathing returned to normal values after drenching infected goats with fenbendazole (at 15 mg/kg b.w.). It is concluded that heavy infections by small lungworms altere the respiratory function, but that alteration is removed rapidly after drenching.

Key words : Respiratory function - Blood gas tensions - Small - lungworms - Goats

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INTRODUCTION

There is some disagreement in the literature concerning the effect of protostrongylid infections on the health of small ruminants due to lesions recorded in lungs of infected hosts. While some authors (Rose, 1959; Festa-Bianchet, 1988; Soulsby, 1965; Georgi, 1974) consider small lungworm infections as a mild helminthiasis, several others disagree with this opinion for sheep (Cabaret, 1981; Dakkak & Ouhelli, 1988; Giangaspero *et al.*, 1993), for goats (Berrag, 1993; Berrag *et al.*, 1994; Berrag & Urquhart, 1996; Berrag & Cabaret, 1997; Nimmo, 1979) and for Bighorn sheep (Forrester, 1971). The importance of protostrongylids in sheep and goats has been poorly studied and their pathogenesis is still unclear.

Hitherto, most of the studies related to ovine and caprine verminous pneumonias have been concerned mainly with its epidemiological aspects either in Morocco (Cabaret *et al.*, 1978; Nimmo, 1979, Berrag & Urquhart, 1996) or in other parts of the world, and systematic pathogenesis investigations of parasitic pneumonias are laking. The mechanics of breathing has been studied in healthy goats (Bakima *et al.*, 1988) and in goats inoculated experimentally with the bacteria *Pasteurella haemolytica* that induced bronchopneumonia (Bakima *et al.*, 1991). No data is available in either sheep or goats on the repercussion of small lungworm infection on respiratory function. Therefore, our study is an attempt to determine whether there was any characteristic changes of the respiratory function (breath/min, arterial blood, pH, partial oxygen and partial carbon dioxide gas tensions) in goats naturally infected with samll lungworms (Nematodea, Protostrongylidae).

MATERIALS & METHODS

1. Animals

Forteen goats were used in this trial. Six goats of local breeds, 3 to 7 years old, weighing 20 to 30 kg, naturally infected by digestive and lung nematodes, were acquired from local farm. They were treated with morantel tartrate (8 mg/kg b.w.) which is only effective against digestive nematodes (Ali Asghar *et al.*, 1976). Another group of eight goats of the same age and weight, free of gastro-intestinal and lungworms parasites, were acquired from the experimental farm of the Institut Agronomique et Vétérinaire Hassan II and acted as controls. They underwent several faecal examinations and were repeatedly treated with fenbendazole at a dose rate of 15 mg/kg b.w. which guaranteed elimination of gastro-intestinal and lung nematodes infection (Dakkak *et al.*, 1979). All animals were kept indoors and fed hay and barely.

2. Clinical and parasitological examinations

Clinical examinations of all animals i.e. breathing rate, auscultation of the chest were carried out every day. The larval excretion was carried out 4 times on 5 g of faeces per goats, using the Baermann technique.

3. Measurements of blood gas tensions

From each animals included in the trial, 5 ml of arterial blood were drawn from the femoral artery using a glass syringe with a 1 inch 23-gauge. The dead space of the needle and syringe were filled with heparin solution 1,000 UI/ml. The syringe was then placed in an ice bath and analysis of blood was done within 5 minutes after its withdrawal. Blood gas pressures were performed by automatic blood gas analyzer machine (AVL 995. Medical Instruments CH8507 Schaffhausen, Switzerland). The measurements were carried out 4 times at 2 days intervals in control (group 1) and infected goats (group 2). Then the infected goats were treated with fenbendazole at dose rate of 15 mg/kg b.w. and left to convalescence during three weeks. This allowed the elimination of worms establishing in the lungs and the rehabilitation of respiratory function to normal level. Goats were then retested for blood gas measurements in order to evaluate the effect of removal of protostrongylids on the respiratory function and the effect of treatment on the improvement of blood gas tensions values.

4. Evaluation of the depression of the respiratory function caused by small lungworms

The disturbance of the respiratory function and the blood gas tension values of goats attributed to small lungworm infections was estimated by calculating the differences between the results obtained between infected and uninfected goats and also by the improvement of data recorded after treatment of infected goats by fenbendazole.

RESULTS

1. Clinical symptoms and parasitological records

Clinical and parasitological records before and after drenching in infected goats are shown in table 1. Before drenching, goats exhibited typical signs of bronchopneumonia i.e. cough, polypnea and nasal discharge mixed with pus. Auscultation revealed the presence of mucous secretion from the airways. The polypnea was severe and averaged 41 ± 11 breaths/min. Larval excretion averaged 1011 ± 332. The main protostrongylid genera were *Muellerius* (77%), *Cystocaulus* (7%), *Protostrongylus* (14%) and *Neostrongylus* (2%). Regular clinical examinations of controls through the trial did not reveal any abnormal respiratory signs. The average breaths/min was 16 ± 4. Several faecal examinations indicated a nil elimination of larvae.

Table 1. Clinical and parasitological data from 6 goats naturally infected with protostrongylids (B) before and 3 weeks (A) after treatment with fenbendazole at a dose rate of 15 mg/kg body weight

Goats No.	Age (years)	L.P.G* B	L.P.G* A	Respiratory rate (Breaths/min) B	Respiratory rate (Breaths/min) A
1	7	800	30	35	12
2	6	670	15	29	15
3	4	1300	23	46	20
4	5	750	25	36	18
5	4	950	30	38	26
6	6	1600	100	62	29
Mean	5	1011	37	41	20
±	±	±	±	±	±
SD	1	332	40	11	6

(*): Parasitological profile of protostrongylid genera were: *Muellerius* (77%), *Cystocaulus* (7%), *Protostrongylus* (14%), *Neostrongylus* (2%).

Controls (No. 7, 8, 9, 10, 11, 12, 13, 14) had an average of 16 ±4 breaths/min and a nil l.p.g.

2. Respiratory parameters

The measurements of blood gas tension in infected goats before and after treatment with fenbendazole and in uninfected goats are shown respectively in tables 2 & 3. The increase in PCO_2 up to 76.97 ± 6.94 mmHg before treatment was accompanied by a diminution of arterial pH (7.18 ± 0.05) and partial pressure of oxygen PO_2 (39.95 ± 8.45 mmHg) while total CO_2 (TCO_2) and HCO_3^- increased up to 41.13 ± 4.88 and 35.05 ± 4.14 mmol/l, respectively. The increase of PCO_2 was accompanied by severe polypnea and the average breaths/min reached 41 ± 11. After drenching of infected goats, an appreciable improvement in respiratory parameters was recorded; the blood gas tensions and the respiratory function returned to normal level (Table 2).

Table 2. Blood gas tension from 6 infected goats by protostrongylids before (B) and at 3 weeks after (A) treatment with fenbendazole at a dose rate of 15 mg/Kg body weight

Goats No.	Treatment	pH	PCO_2 (mmHg)	PO_2 (mmHg)	TCO_2 (mmol/l	HCO_3^- (mmol/l)
1	Before (B)	7.16	70.23	35.15	44.20	31.55
	After (A)	7.33	42.50	84.25	26.32	24.60
2	B	7.22	72.80	52.65	35.58	28.60
	A	7.39	34.65	72.02	20.61	19.75
3	B	7.17	69.40	38.20	37.60	35.20
	A	7.38	38.55	80.30	24.80	26.20
4	B	7.27	81.20	41.85	40.90	41.20
	A	7.40	50.20	72.65	26.60	23.50
5	B	7.16	79.10	46.10	38.30	35.20
	A	7.38	42.30	95.55	20.30	20.05
6	B	7.10	89.10	25.80	50.20	38.40
	A	7.43	44.26	69.38	30.82	28.62
	Before	7.18	76.97	39.95	41.13	35.05
		±	±	±	±	±
Mean		0.05	6.94	8.45	4.88	4.14
± SD		7.43	42.07	79.02	26.36	23.78
	After	±	±	±	±	±
		0.02	4.80	8.98	3.17	3.16

Table 3. Blood gas pressures values from 8 goats free of lungworms and gastro-intestinal nematodes

Goats No.	Age (years)	pH	PCO_2 (mmHg)	PO_2 (mmHg)	TCO_2 (mmol/l)	HCO_3^- (mmol/l)
7	4	7.39	41.10	75.40	22.10	16.15
8	3	7.46	37.30	85.65	24.10	21.30
9	3	7.40	40.90	94.70	26.65	22.60
10	4	7.42	39.85	80.25	24.25	24.20
11	5	7.35	37.10	79.10	28.05	26.10
12	4	7.34	41.50	70.95	22.45	23.10
13	5	7.42	34.85	92.35	21.74	20.50
14	3	7.44	46.25	80.30	20.95	18.80
Mean	4	7.40	39.85	82.33	23.78	21.59
±	±	±	±	±	±	±
SD	0.78	0.03	3.26	7.58	2.33	2.93

3. Estimate of the effect of small lungworm infection of goats on the respiratory function

The alteration caused by small lungworm infections in goats on the respiratory function is illustrated in table 4. It appears that protostrongylids putatively lowered the pH by 0.22 and the PO_2 by 42.38 mmHg, and increased the PCO_2 by 37.12 mm Hg and HCO_3^- by 13.46 nmol/l. Beside that, they increased breathing by 25 breaths/min.

Table 4. Tentative effects of small lungworms infections in goats on the respiratory function.

Goats No.	pH	PCO_2 (mmHg)	PO_2 (mmHg)	TCO_2 (mmol/l)	HCO_3^- (mmol/l)	L.P.G.	Breaths/ min
Infected	7.18*	76.97	39.95	41.13	35.05	1011	41
goats	±	±	±	±	±	±	±
	0.05	6.94	8.45	4.88	4.14	332	11
Uninfected	7.40	39.85	82.33	23.78	21.59	0	16
goats	±	±	±	±	±		±
	0.03	3.26	7.58	2.33	2.93		4
Differences	0.22	37.12	42.38	17.35	13.46	1011	25

* : average ; ±: standard deviation

DISCUSSION

This is a first report on the pathogenesis of caprine parasitic pneumonias and confirms that small lungworm infections may interfere with health of infected goats and induce a significant debilitation.

Data reported in this work provide a strong evidence of the direct effect of protostrongylids in causing a respiratory disorders in naturally infected goats. The most striking and significant feature of the results found in infected goats is the marked increases in PCO_2 up to 76.97 ± 6.94 accompanied by a low arterial pH of 7.18 ± 0.05, an increased HCO_3^- of 35.05 ± 4.14 mmol/l, and the exceedingly high polypnea (41 ± 11 breaths per min.) compared to uninfected goats (Tables 2 & 4). This agrees with the findings in goats with *Pasteurella multocida* pulmonary infection (Bakima *et al.*, 1991): the pH is also lowered and the breaths/min are increased. This condition would probably indicate a respiratory acidosis.

According to Coffman (1980) and Mc Intyre (1983), respiratory acidosis is defined as an abnormal increase in blood PCO_2, associated with a decrease in the blood pH. Metabolic processes in the body are continuously producing hydrogen ions (H^+) and these are regulated by both the lungs and kidneys so that blood pH is maintained within narrow limits at approximately 7.40 (Carter & Brost, 1969; Kinter, 1967). Carbon dioxide (CO_2) produced by cells reacts with water in the presence of carbonic anhydrase to form carbonic acid (H_2CO_3), which dissociates to form H^+ and HCO_3^-. The resultant elevation of CO_2 and concentration of H^+ (lowered pH) occurs as a result of failure of the lungs to excrete CO_2. The continuing production of CO_2 from tissue metabolism may results in increased plasma acid carbonic and carbon dioxide which in turn stimulates the respiratory center and responsible for the polypnea recorded in infected goats (41 ± 11 breaths per min) compared to uninfected goats (16 ± 4 breaths per min). The respiratory center can not correct for this acidosis when lungs are damaged (Brobst, 1975).

In such cases, however, the kidneys respond to the increased PCO_2 by increasing the rate of H^+ secretion and HCO_3^- regeneration which would explain the level of HCO_3^- of 35.05 ± 4.14 mmol/l recorded from infected goats compared to controls (21.59 ± 2.93 mmol/l). Among the causes of hypoventillation are pulmonary oedema, compensation for a metabolic alkalosis, airway obstruction, chronic pulmonary diseases (small lungworm infection in present study) (McIntyre 1983; Brugere, 1985). In such cases, the usual laboratory findings are low blood pH, high PCO_2, and increased HCO_3^- (Atkins 1969).

Lungworm genera identified were: *Muellerius*, *Cystocaulus* and *Protostrongylus* and to limitent extent, *Neostrongylus*, at level of 1011 ± 332 l.p.g. which is likely to be of pathologic significance in causing alveolitis, bronchiolitis and bronchitis.

It would seem probable that infections with several lungworm species exert a synergistic pathological effect responsible for chronic verminous bronchopneumonia commonly seen in grazing sheep and goats (Berrag & Urquhart, 1996; Berrag *et al.*, 1996; Bouljihad *et al.*, 1995).

Respiratory nematode infections of goats and sheep are widespread in Morocco and are probably one of the most important causes of mortality and morbidity with consequent loss in production (Dakkak & Ouhelli, 1988; Berrag *et al.*, 1994). The direct effect of small lungworm infections on the

respiratory disorders in goats is clearly shown as deworming of infected goats with fenbendazole leads back to normal values of some respiratory parameters (Table 2). This direct effect could explain the higher prevalence of lungworms in sheep with respiratory viruses (Giangaspero *et al.*, 1993).

It can be drawn from this study that parasitic bronchopneumonias associated with proto-strongylids may compromise the health and the productivity of infected goats and probably sheep via a disturbance in acid-base balance of the body and alteration of the respiratory function.

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