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Susceptibility of Nubian goats to mercury poisoning in the Sudan

AHMED (K.E.), ADAM (S.E.I.), IDRIS (O.F.), WAHBI (A.A.). Sensibilité des chèvres nubiennes à l'intoxication par le mercure au Soudan. *Revue Élev. Méd. vét. Pays trop.*, 1991, **44** (2) : 123-129

Douze chèvres nubiennes ont reçu des doses orales uniques ou répétées de chlorure de mercure à 10, 20 et 40 mg/kg de poids vif. Elles sont mortes ou ont été sacrifiées in extremis 18 heures à 18 jours après administration. Les signes majeurs de l'intoxication ont été les suivants : anorexie, écume à la bouche, détresse respiratoire, épistaxis, météorisation, diarrhée, attitudes anormales et décubitus. Les auteurs ont mis en évidence, dans le sérum, une augmentation de l'activité de la GO transaminase, des concentrations plus élevées en urée et en phosphates inorganiques, une diminution des protéines totales et de la concentration en calcium. Les principales lésions du rein ont été la dilatation et la nécrose des tubes contournés, le rétrécissement et la disparition des amas glomérulaires, la présence de quantités variables de matériaux acidophiles homogènes dans la lumière des tubes affectés. On a noté également de l'entérite, la dégénérescence ou la nécrose des cellules hépatiques, de la congestion pulmonaire, des hémorrhagies, de l'oedème et de l'emphysème. Les modifications de la formule sanguine ont révélé une anémie. *Mots clés* : Chèvre nubienne - Intoxication - Chlorure de mercure - Toxicité - Soudan.

INTRODUCTION

The toxic effect of mercury coumpounds has been studied in different species including cattle (1, 8, 9, 21), sheep (8, 21), horses (14), dogs and cats (3, 12) and poultry (13, 17). The mechanisms of actions of mercury and heavy metals have been described in details by OEHME (11).

It is well known that as more is learned about environment hazards, decisions can be made from a base of knowledge either to limit the use of a dangerous substance or to tolerate a minimal risk. Given both the lack of data regarding the proper assessment of mercury toxicosis in the Sudan and the ability of mercury to interact with other metals in newly established industrialized areas in the third world this study is intended to present the clinical, biochemical and pathological abnormalities associated with experimental mercuric chloride toxicosis in Nubian goats.

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* British Drug Houses, England.

MATERIALS AND METHODS

Animals

Fifteen 6-month-old Nubian goats of both sexes were used. The animals were clinically healthy and housed in pens within the premises of the Central Veterinary Research Laboratory, Soba, and fed a concentrate ration plus forage sorghum and water *ad libitum*.

Administration of mercuric chloride

The goats were allotted to four groups. Mercuric chloride (purity not less than 97 %)* was dissolved in water and given by drench as single dosages of 40 mg/kg to goats 32 to 37 (group 1) and daily dosages of 20 mg/kg/day to goats 38 to 40 (group 2) and 10 mg/kg/day to goats 41 to 43 (group 3). Goats 44, 45 and 46 were kept as undosed controls (group 4). Clinical observations were recorded and correlated with pathology, haematology and clinical chemistry alterations.

Blood samples

Blood samples obtained from the jugular vein on two occasions (on day-15 and day-0 prior to treatment) provided a pretreatment baseline. Additional blood samples were drawn for serum analysis and haematology on days 1 to 18 after initiation of the treatment.

Haematological methods

Jugular blood samples were collected into clean dry vials containing EDTA. Packed cell volume (PCV), haemoglobin concentration (Hb), total counts of red and white blood cells (RBC and WBC), mean corpuscular volume (MCV)

and mean corpuscular haemoglobin concentration (MCHC) were determined by the methods described by SCHALM (15).

Chemical methods

Blood samples were allowed to clot and sera were separated and analysed for the activities of glutamic oxaloacetic transaminase (GOT), glutamic pyruvic transaminase (GPT), and gamma glutamyl transferase (γ-GT) and for the concentrations of total cholesterol and uric acid by commercial kits*. The concentrations of urea (5), sodium and potassium (19) magnesium (16), calcium (18), inorganic phosphate (19) and total protein (20) were measured by standard methods.

Histopathological methods

Tissues were fixed in 10 % formal-saline and paraffin sections stained with haematoxylin and eosin (H & E). Selected sections were stained with Prussian blue reaction for the demonstration of haemosiderin.

Statistical analysis was performed using ANOVA analysis. Data are presented as means ± SEM.

RESULTS

The dosing schedule and time of death of mercuric chloride-poisoned goats are given in table I.

TABLE I Details of goats given mercuric chloride by drench.

Group	Goat No.	Sex	Age (months)	Dose of mercuric chloride (mg/kg)	Time of death
1	32	F	6	40 (single dose)	18 hours
	33	F	6	40 (single dose)	47 hours
	34	F	6	40 (single dose)	79 hours
	35	M	6	40 (single dose)	6 days
	36	M	6	40 (single dose)	7 days (killed in extremis)
	37	M	6	40 (single dose)	8 days
2	38	F	6	20 (repeated doses)	25 hours
	39	F	6	20 (repeated doses)	45 hours
	40	M	6	20 (repeated doses)	6 days
3	41	M	6	10 (repeated doses)	6 days
	42	F	6	10 (repeated doses)	6 days
	43	M	6	10 (repeated doses)	18 days

* Boehringer Mannheim GmBH Diagnostica, West Germany.

Clinical findings

Goats 32 to 37 (group 1) receiving single dosages of mercuric choloride (40 mg/kg), showed restlessness, salivation, blood from the nostrils (photo 1), inappetence, dyspnoea, diarrhoea, arching of the back, tremor, paresis of the hind limbs, recumbency and lateral deviation of the head and neck and died or were killed *in extremis* 18, 47 and 79 hours and 6, 7 and 8 days respectively, after dosing. Goats 38, 39 and 40 (group 2) given daily dosages of mercuric chloride (20 mg/kg), developed salivation, inappetence, dyspnoea, epistaxis, diarrhoea, tremor and recumbency and died 25 to 45 hours and 6 days, respectively after dosing. In goats 41, 42 and 43 (group 3) receiving daily dosages of the drug (10 mg/kg), the clinical signs were similar to those observed in animals in groups 1 and 2 but salivation and arching of the back were less marked. These goats died on days 6, 6 and 18, respectively. There were no clinical changes in control goats 44, 45 and 46 (group 4).

Photo 1 : Epistaxis in goat 35 (group 1), given an oral dose of 40 mg/kg of mercuric chloride.

Post-mortem findings

These are summarized in table II. In goats of groups 1, 2 and 3, there were haemorrhages and congestion in the abomasum, intestines, liver, kidneys, heart and lungs, abomasitis enteritis and renal degeneration. Pulmonary oedema and emphysema and distension of the gall bladder with thick dark greenish bile were especially seen in goats of groups 1 and 2. No significant lesions were seen in the control goats of group 4.

TABLE II Post-mortem findings in goats dosed with mercuric chloride.

Site	Findings	Group		
		1	2	3
Rumen, reticulum and omasum	Congestion	+++	++	+
Abomasum and intestines	Haemorrhagic or catarrhal abomasitis and enteritis and erosions	+++	++	++
Liver	Congestion and haemorrhage	+++	++	++
Heart	Congestion and haemorrhage	++	++	++
Kidney	Congestion, haemorrhage and degeneration	+++	+++	++
Lung	Congestion and haemorrhage Oedema and emphysema	+++ +++	+++ ++	++ ++
Serous cavities	Hydrothorax, hydropericardium and hydroperitoneum	(–)	(–)	(–)

+... +++ : increasing severity of lesions. (–) : absence of lesions.

Histological findings

There was a severe dilatation and necrosis of many renal convoluted tubules (photos 2, 3) congestion, haemorrhage, disappearance of the renal glomerular tufts, congestion of the hepatic blood vessels and sinusoids, and fatty change and/or necrosis of the centrilobular hepatocytes in goats of group 1. These changes were less marked in groups 2 and 3. Congestion of the pulmonary alveolar capillaries, haemorrhage into alveoli and pulmonary oedema and emphysema were marked in goats of group 1. Varying amounts of haemosiderin deposits in the splenic red pulp and of acidophilic homogeneous substance in the affected renal tubules, congestion and haemorrhage in the cardiac muscle fibres were seen in mercuric chloride-poisoned goats. There were no significant lesions in the control goats (group 4).

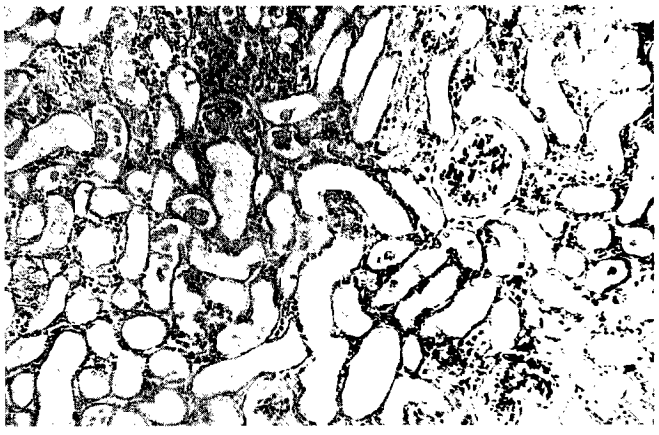

Photo 2 : Dilatation of the renal convoluted tubules of goat 35 (group 1), given an oral dose of 40 mg/kg of mercuric chloride (x 70).

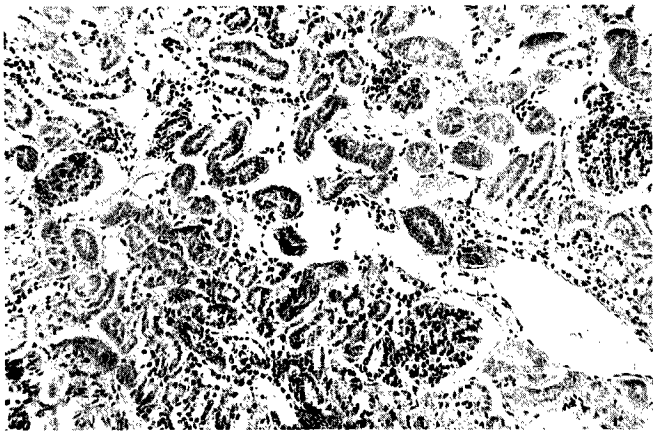

Photo 3 : Necrosis of the renal convoluted tubules of goat 37 (group 1), given an oral dose of 40 mg/kg of mercuric chloride (x 70).

Changes in serum constituents

These are presented in table III and figures 1, 2, 3, referring to the corresponding groups 1, 2, 3. Statistical analysis of the values showed that mercuric chloride significantly increased the activity of GOT and concentration of urea and significantly decreased the levels of total protein and calcium in the serum compared to control goats. Although mercuric chloride did not cause any significant difference in the serum inorganic phosphate concentration of groups 1 and 3 there was a significant increase in serum inorganic phosphate concentration in goats of group 2. The level of serum potassium fluctuated within the normal range. There were no significant differences in serum magnesium, sodium cholesterol, uric acid, GPT and γ-GT between the test groups and the control group.

Haematological changes

In goats of groups 1, 2 and 3 which died within 6 days of dosing, the overall increases in Hb, PCV and RBV were not statistically significant compared to the control group. There were insignificant differences in MCV and MCHC values between the test and control groups. The terminal leucocytosis was caused by an increase in the number of neutrophils. In goats which survived for more than 7 days, there were significant decreases in Hb, PCV and RBC counts and insignificant changes in the values of MCV, MCHC and WBC counts.

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***TABLE III** Effect of mercuric chloride on serum constituents in Nubian goats.*

Group	GPT (i.u.)	GOT (i.u.)	γ-GT (i.u.)	Cholesterol (mg/100 ml)	Total protein (g/100 ml)	Urea (mg/100 ml)	Uric acid (mg/100 ml)	K (mg/100 ml)	Na (mg/100 ml)	Ca (mg/100 ml)	P (mg/100 ml)	Mg (mg/100 ml)
G_1	3 ± 0.0^{a}	29.2 ± 6.9^{abc}	40.9 ± 2.5^{a}	76 ± 10.07^{a}	4.9 ± 0.35^{a}	142.7 ± 24.2^{a}	1.8 ± 0.2^{a}	17.65 ± 0.35^{a}	271.9 ± 12.1^{a}	6.9 ± 1^{a}	6.1 ± 0.22^{ac}	3.6 ± 0.4^{a}
G_2	4 ± 0.41^{a}	36.5 ± 6.1^{ab}	42.2 ± 5.2^{a}	71.6 ± 2.5^{a}	5.6 ± 0.32^{ab}	225.3 ± 17^{ac}	2 ± 0.82^{a}	13.4 ± 1^{bcd}	275.6 ± 4.7^{a}	7.9 ± 0.4^{ab}	10.4 ± 0.3^{b}	2.6 ± 0.01^{a}
G_3	2.3 ± 0.64^{a}	29.1 ± 4.68^{abc}	38.9 ± 5.6^{a}	87.1 ± 28.5^{a}	5.8 ± 0.34^{bc}	254.2 ± 44.7^{c}	2.6 ± 0.09^{a}	12.6 ± 1.1^{cd}	254.4 ± 18.1^{a}	8.6 ± 0.20^{bc}	6 ± 0.47^{c}	2.8 ± 0.15^{a}
G_4	3.6 ± 0.4^{a}	15.9 ± 0.39^{c}	34.9 ± 3.1^{a}	66.8 ± 8.8^{a}	6.36 ± 0.06^{c}	22.5 ± 3.4^{b}	1.9 ± 0.46^{a}	14.3 ± 0.92^{d}	276.3 ± 4.7^{a}	10.4 ± 0.2^{c}	7 ± 0.33^{d}	2.8 ± 0.17^{a}

Means with different superscripts vertically for each parameter are significantly different ; a-d, $P < 0.05$.

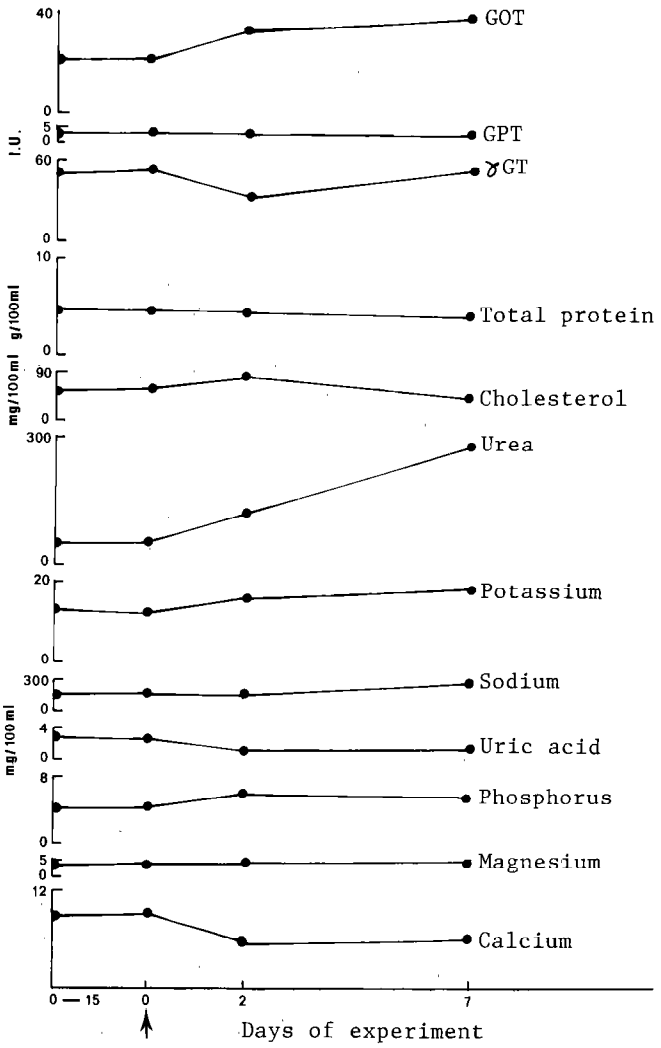

Fig. 1 : Changes in serum constitue uts in group 1.

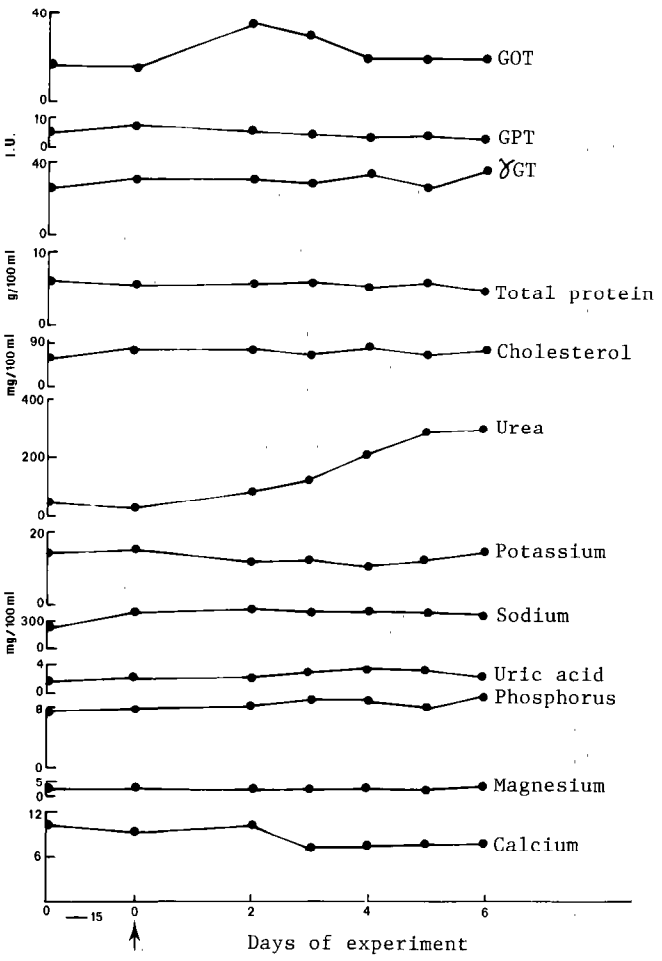

Fig. 2 : Changes in serum constituents in group 2.

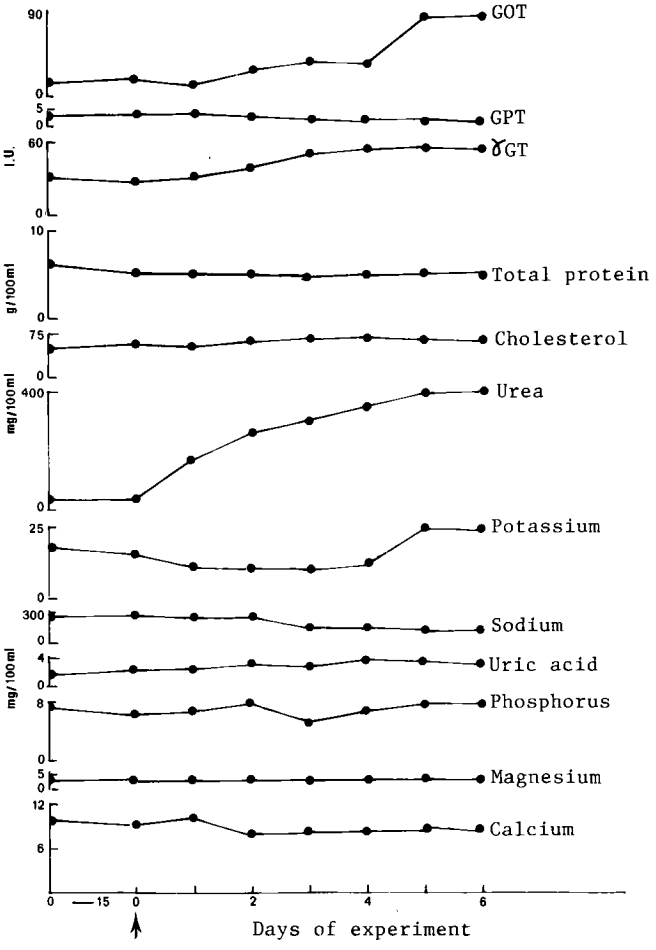

Fig. 3 : Changes in serum constituents in group 3.

DISCUSSION

The results of this study indicate that Nubian goats given an oral dosage of mercuric chloride at 40 mg/kg succumbed to death or were killed in a moribund condition between hour 18 and day 8. On the other hand, the goats receiving repeated daily doses of mercuric chloride at 20 and 10 mg/kg died after different time intervals (25 hours-18 days). The main signs of mercuric chloride poisoning in goats were salivation, blood from the nostrils, incoordination, dyspnoea, diarrhoea, arching of the back, tremor and ataxia. In the present study, we have not examined the lesions in the CNS. Previous studies of organic mercury toxicoses in dogs and cats (3) have demonstrated loss of nerve cells and replacement with reactive and fibrillary gliosis and degeneration of the granular layer of some of the Purkinje neurones in the cerebellum. Pulmonary oedema, emphysema, congestion and/or haemorrhage might have caused dyspnoea. The marked renal lesions may be the cause of arching of the back in mercury-poisoned goats.

In this study, renal impairment was the consistent physiochemical abnormality in mercury-poisoned goats and was observed to be an early and important event in the pathogenesis of the disease. The prominent renal lesions comprised marked dilatation and necrosis of the proximal convoluted tubules, shrinkage and/or necrosia of the glomerular tufts, congestion of the blood vessels and varying amounts of acidophilic homogeneous material in the lumina of the affected tubules. These histopathological changes were accompanied by marked increases in the concentrations of urea and decreases in the levels of calcium and total protein in the serum. CORNELIUS and KANEKO (4) suggested that the total serum protein concentration represents the balance between the process of biosynthesis and catabolism or loss by haemorrhage or proteinuria. The same authors mentioned that severe haemorrhage in rats and dogs was accompanied by a decrease in the total concentraion of plasma protein. The renal lesions associated with mercuric chloride poisoning in goats are similar to those described in *Calotropis procera*- intoxicated Nubian goats by MAHMOUD *et al.* (10). Of particular interest is the finding of renal impairment in the early stages of the disease in all mercury-poisoned goats. This was indicated by the sharp and early rise in the concentration of urea in the serum and concurrent hypoproteinemia. However, serum potassium did not significantly change in mercury-dosed goats. The increases in the concentration of inorganic phosphate and decreases in the level of calcium in the serum of mercury-poisoned goats could have resulted from renal damage. BENTINCK-SMITH (2) suggested that renal damage leads to the retention of phosphate which in turn results in a reduced absorption of calcium from the intestine and a lower concentration of calcium in the serum. It seems that mercury in the animal body can be stored in the proximal convoluted tubules of the kidneys (11, 22).

The increase in the values of Hb, PCV and RBC may have resulted from haemoconcentration. However, the anaemia noticed in mercury-poisoned goats surviving for more than 7 days may be described as normocytic normochromic in the majority of the goats due to slight changes in both MCV and MCHC values.

It might therefore be concluded that Nubian goats like cattle and sheep (1, 12) are susceptible to mercury and that renal impairement is an important finding of the toxicoses in which the metal is probably excreted in considerable amounts in the urine. No studies have so far been carried out on mercury poisoning in camels.

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AHMED (K.E.), ADAM (S.E.I.), IDRIS (O.F.), WAHBI (A.A.). Susceptibility of Nubian goats to mercury poisoning. *Revue Élev. Méd. vét. Pays trop.*, 1991, **44** (2) : 123-129

Twelve Nubian goats were given single or repeated oral dosages of mercuric chloride at 10, 20 and 40 mg/kg and died or were killed in extremis at various times after dosing (18 hours-18 days). The main signs of poisoning were anorexia, frothing at the mouth, respiratory distress, epistaxis, bloat, diarrhoea, abnormal posture and recumbency. An increase in the activity of GOT and in the concentrations of urea and inorganic phosphate and a decrease in total protein and calcium concentrations in the serum were detected. The main lesions were dilatation and necrosis of the proximal convoluted tubules, shrinkage and disappearance of the glomerular tufts, varying amounts of acidophilic homogenous material in the lumens of the affected tubules of the kidney, enteritis, hepatocellular degeneration and/or necrosis and pulmonary congestion, haemorrhage, oedema and emphysema. The changes in the red blood cells indicated anaemia. *Key words* : Nubian Goat - Poisoning - Mercuric chloride - Toxicity - Sudan.

AHMED (K.E.), ADAM (S.E.I.), IDRIS (O.F.), WAHBI (A.A.). Sensibilidad a la intoxicación por mercurio en cabras de raza nubiana en Sudán. *Revue Élev. Méd. vét. Pays trop.*, 1991, **44** (2) : 123-129

Doce cabras nubianas recibieron dosis orales, únicas o repetidas, de cloruro de mercurio de 10, 20 y 40 mg/kg de peso vivo. Todos los animales murieron o fueron sacrificados *in extremis* entre 18 horas y 18 días post administración. Los principales signos de intoxicación fueron los siguientes : anorexia, ecumesis bucal (salivación), dificultad respiratoria, epistáxis, timpanismo, diarrea, actitudes anormales y decúbito. Se evidenció un aumento de la actividad de la GO transaminasa en suero, concentraciones más elevadas en urea y en fosfatos orgánicos, una disminución de las proteinas totales y de la concentración de calcio. Las principales lesiones renales fueron dilatación y necrosis de los tubulos contorneados, disminución y desaparición de los grupos glomerulares, cantidades variables de materiales acidófilos homogéneos en el lumen de los tubos afectados. Se observó igualmente enteritis, degeneración o necrosis de las células hepáticas, congestión pulmonar, hemorragias, edema y enfisema. Las modificaciones de la fórmula sanguínea revelaron anemia. *Palabras claves* : Cabras nubiana - Intoxicación - Cloruro de mercurio - Toxicidad - Sudán.

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