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CONGENITAL GOITER AND MINERAL IMBALANCE IN GOAT KIDS

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SUMMARY

The aim of the present study was to investigate the relationship between thyroid function and some macro- and micro elements in goats. Fourteen Egyptian goat kids of different ages (4-45 days) suffering from congenital goiter were operated (hemithyroidectomy) throughout a period of four years (1995-1999). Serum constituent levels of Triiodothyronine (T3), Thyroxine (T4), Thyroid-Stimulating hormone (TSH), Protein-bound iodine (PBI), Calcium, inorganic phosphorus, magnesium, iron, copper, Zinc, Cobalt and Selenium were estimated in affected Kids and their dams pri and post the operation. There was a significant decrease in serum concentrations of T3, T4, TSH, PBI, Zinc, Cobalt and selenium, while magnesium and copper levels showed a significant increase in affected kids' dams. There was significant decrease in serum concentrations of T4, TSH, PBI, Zinc, Cobalt and Selenium while T3, magnesium and copper values were significantly increased in kids with hypothyroidism. No significant change was observed in calcium, inorganic phosphorus and iron levels neither in goitrous kids nor their dams. Ten days post thyroidectomy, the mean serum concentrations of T3, T4 and PBI were significantly increased while TSH decreased significantly in the affected kids. There was slight hypocalcaemia, depression of magnesium and copper near to normal levels while the mean zinc level was increased but not significantly. Cobalt and selenium showed no improvement post operation. Daily examination, revealed complete resolution of clinical signs especially thyroid enlargement in 11 out of 14 kids within 2 weeks after the operation.

It is possible to say that deficiency of cobalt and

selenium in dams may play a role to cause congenital goiter in their kids and that the homeostasis of magnesium, copper and zinc is altered during hypothroidism. Also it can be said that the hemithyroidectomy can be followed as a therapeutic surgical procedure in goat kids suffering from the disease..

INTRODUCTION

The thyroid gland contains, two separate groups of hormone-synthesize cells. The parafollicular cells produce calcitonin and the follicular cells produce thyroid hormones Triiodothyronine "T3" and Thyroxine "T4" under the control of Thyroid-stimulating hormone "TSH". The "TSH" is secreted in the blood plasma in response to the hypothalamic thyroid-releasing hormone (TRH) in response to lowered plasma levels of T3 and T4. (Gray, et al 1985; Alan & James 1995 and Kooistra et al., 2000).

Thyroid hormones control tissue growth and metabolism by the regulation of cellular oxidation. Both hormones are bound in the blood to the plasma proteins, "T4" being more firmly bound than ìT3î. The organic iodine or protein-bound iodine (PBI) reflects thyroid hormone activity while plasma thyroxine gave good indication of iodine deficiency and correlated well with the occurrence of goiter (Underwood, 1977).

Ninety percent of the iodine circulating in the blood is in the form of "T4" which is the precursor of the biologically active hormone, "T3" under the control of the enzyme thyroxin-5-monodeiodinase (Leonard and Visser, 1986).

Thyroid hyperplasia or goiter can be associated with either low or high concentrations of thyroid hormones. In ruminants, hypothyroidism is the commonest type of thyroid disorder encountered (Wilson, 1975).

In hypothyroidism, the lowered output of thyroid hormones triggers off excess production of "TSH" which stimulate the production of thyroid hyperplasia or goiter (Alan and James, 1995).

Disorders of the thyroid gland comprised a group of commonly encountered endocrinological diseases. Many of these disorders reflected genetic, dietary and environmental aetiology (Wither, 1997).

The role of nutritional factor with an emphasis on micro-nutrients has been explored. There is increasing experimental evidence that suboptimal intake of some mineral elements can influence thyroid hormone status. (Lukaski and Smith, 1995). Although iodine deficiency is the main cause of goiter, it is possible that deficiency of iron, copper, zinc, cobalt and selenium may play a role to impair thyroid hormone metabolism and impact circulating thyroid hormone concentrations, resulting in hypothyroidism. (Underwood, 1977; Mocan, et al 1989; Arther, et al. 1990 and Lukaski et al. 1995). On the other hand, thyroid hormones are known to affect the metabolism of some mineral elements. Marked alterations in the homeostasis of calcium, magnesium, copper and zinc have been reported in thyroid diseases (Rude, 1993, Burman et al., 1976 and Dolev, et al., 1988).

In the present study, to establish a relationship between the thyroid state and the mineral status, the intra-individual changes between hypo and euthyroid state as well as post thyroidectomy in the corresponding minerals status indexes were studied.

MATERIALS AND METHODS

Case history and clinical evaluation:

Fourteen Egyptian goat kids 4-45 days old (9 males and 5 females) were admitted to the Surgery and Medicine Clinics, Faculty of Veterinary Medicine, Cairo University, from October, 1995 to June, 1999, with history of bilateral subcutaneous swelling in the upper part of neck. The inquiry about the ration failed to reveal the correct daily ration of their dams during pregnancy, and no reliable estimate could be made of the daily minerals intake. Green fooder especially barseem (Trifolium Alexandrinum), was understood to be highly use.

The goat kids were clinically examined and varying degrees of thyroid enlargement associated with signs of incordination, poor suckling, inability to stand, and limb weakness were observed (Fig. 1). Rectal Temperature was 38.8 ± 0.251°C, heart and respiratory rates were 158.4 ± 6.013 and 55.2 ± 2.332 per minute respectively.

Laboratory Evaluation:

Thyroid hormone assay: on day 0 (before operation) blood samples were collected by Veinpuncture from five clinically normal kids (control), their dams, fourteen kids with hypothyroidism and their dams. Serum was separated, frozen at -20°C and stored for estimation of "T3", "T4", "TSH" and ìPBIî levels using ELISA kits according to the method adopted by Schall (1978).

Minerals profile:

serum calcium, magnesium, iron, copper zinc were determined by means of Atomic absorption spectrophotometer according to the method of Fernandez and Kahn (1971).

Serum inorganic phosphorus value was estimated using kits according to Goledenberg (1966).

Serum selenium content was determined by means of a Graphite-furnace Tube Atomizer (GTA) for graphite furnace AAS according to Hoening (1986).

Surgical management:

According to Graves et al. (1994) and Carmal Mooney (1996), unilatral thyroidectomy was performed to all kids showing signs of goiter (Fig. 2).

Statistical significance was assessed by the unpaired student t-test and f-test (Snedecor and Cochran, 1967).

RESULTS

Results of hormonal assay revealed a significant decrease ($P < 0.05$) in serum concentrations of T3, T4, TSH and PBI in affected kidsí dams (Table 1).

The T3 serum concentration was significantly increased ($P < 0.05$) while T4, TSH and PBI concentration were significantly decreased ($P < 0.05$) in kids with hypothyroidism (Table 2).

Ten days post hemi thyroidectomy, the mean serum concentrations of T3, T4 and PBI were significantly increased ($P < 0.05$) while TSH decreased significantly ($P < 0.05$) in kids with hypothroidism (Table 2).

Concerning minerals and micro-elements profile, there was a significant decrease in serum cobalt ($P < 0.01$), zinc and selenium ($P < 0.05$) while a significant increase ($P < 0.05$) in serum magnesium and copper in affected kids' dams was observed (Table 1).

Serum magnesium and copper concentrations significantly increased ($P < 0.05$), meanwhile there was significant decrease in cobalt ($P < 0.01$), zinc and selenium ($P < 0.05$), values in the goitrous kids compared with control (Table, 2). No significant changes were observed in concentrations of calcium, inorganic phosphorus and iron neither in serum of goitrous kids nor their dams.

Ten days post operation, there was slight hypocalcaemia, while the levels of both magnesium and copper were near the normal levels, the zinc level was increased but not significantly (Table 2). The cobalt and selenium concentrations showed no significant improvement after the operation.

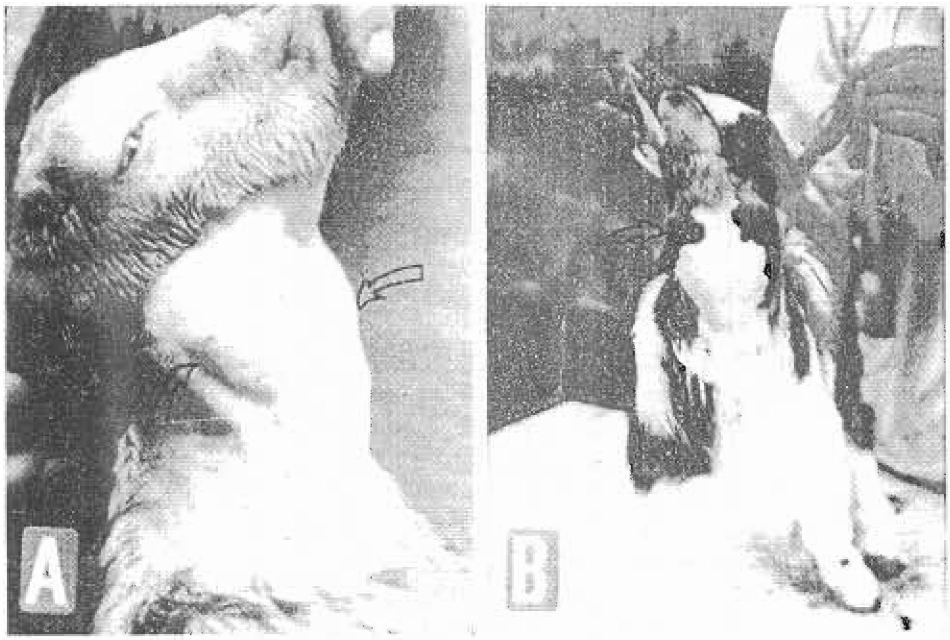

Fig. 1 (A & B) Lateral and front views showing bilateral enlargement of the thyroid gland.

Fig. (2,A): Front view: showing pre-surgical enlargement of the thyroid gland.
(B): Latral view: showing resolution of thyroid enlargement ten days post-hemithyroidectomy.

Table (1): Serum hormones and mineral concenterations in dams of control and affected kids.

	Total T_3 (ng/dl)	Total T_4 (µg/dl)	TSH (µU/dl)	PBI (µg/dl)	Calcium (mg/dl)	Phosphorus (mg/dl)	Magnesium (mg/dl)	Iron (µg/dl)	Copper (µg/dl)	Zinc (µg/dl)	Cobalt (µg/dl)	Selenium (µg/dl)
Control	177.400 ± 3.815	10.400 ± 0.570	1.900 ± 0.063	7.200 ± 0.070	9.280 ± 0.193	4.240 ± 0.163	4.053 ± 0.308	562.67 ± 13.57	75.837 ± 2.304	72.630 ± 3.140	29.667 ± 2.87	19.203 ± 0.628
Affected	132.600* ± 2.181	7.820* ± 0.329	1.300* ± 0.031	5.320* ± 0.037	9.300 ± 0.070	4.080 ± 0.037	5.047* ± 0.226	558.33 ± 14.33	83.690* ± 1.741	66.000* ± 1.880	13.383** ± 2.489	16.983* ± 0.784

Mean ± standard error

* $P < 0.05$

** $P < 0.01$

Table (2): Serum hormones and mineral concenterations in control, affected and hypothyroidectomised kids.

	Total T_3 (ng/dl)	Total T_4 (µg/dl)	TSH (µU/dl)	PBI (µg/dl)	Calcium (mg/dl)	Phosphorus (mg/dl)	Magnesium (mg/dl)	Iron (µg/dl)	Copper (µg/dl)	Zinc (µg/dl)	Cobalt (µg/dl)	Selenium (µg/dl)
Control Kids	$196.400^{a} \pm 3.802$	$11.380^{c} \pm 0.329$	$1.660^{b} \pm 0.024$	$7.640^{c} \pm 0.024$	8.992 ± 0.425	4.240 ± 0.240	$4.153^{a} \pm 0.226$	579.300 ± 15.684	$88.623^{a} \pm 2.821$	$95.583^{a} \pm 3.394$	$35.800^{a} \pm 2.760$	$20.180^{b} \pm 1.397$
Affected Kids	$215.000^{b} \pm 4.183$	$9.900^{b} \pm 0.352$	$1.040^{a} \pm 0.102$	$6.240^{b} \pm 0.024$	9.500 ± 0.063	5.000 ± 0.063	$5.080^{b} \pm 0.234$	567.000 ± 17.899	$103.830^{b} \pm 4.841$	$86.867^{b} \pm 1.471$	$24.186^{c} \pm 2.936$	$16.083^{c} \pm 1.149$
10 days post-thyroidectomy	$286.800^{d} \pm 1.200$	$11.100^{d} \pm 0.268$	$0.800^{d} \pm 0.063$	$7.840^{d} \pm 0.024$	8.800 ± 0.031	5.200 ± 0.126	4.630 ± 0.311	558.000 ± 14.343	95.950 ± 3.008	89.420 ± 2.131	$24.713^{c} \pm 3.477$	$17.226^{d} \pm 0.868$

Mean ± standard error

a-b, a-d, b-c, b-d ($P < 0.05$)

a-c ($P < 0.01$)

DISCUSSION

The condition of hypothyroidism in goat kids has been reported on several occasions (Alan & James, 1995; Bires et al., 1996; and Abdel Gadir & Adam, 1999). Clinical symptoms and biochemical findings in this study were similar to hypothyroid goiter as mentioned in earlier affected goat kids.

Thyroid enlargement and signs of incordination were the most common clinical signs of the affected kids. This was concurrent with that described by Baxter, (1986); Capen, (1995), and Messer et al. (1995).

The present biochemical findings (T3, T4, PBI) of mother dams of the affected kids revealed a decrease in its concentrations than that found in the normal dams. A primary iodine deficiency in the dams may be the cause of congenital goiter in their kids, this result agrees with that obtained by Capen, (1995) and Bires et al., (1996).

Hypothyroid goiter evaluation in the current study was based on determination of "T4" concentration and this concurred with Li et al., (1986); Graves et al., (1994) and Panciera, (1994) who stated that serum "T4" determination is accepted method of thyroid function evaluation than T3 because the thyroid gland stores much higher amounts of ìT4î than "T3" and "T3" is mainly produced by deiodination of "T4" in peripheral tissues.

The condition of hypothyroid goiter in goat kids described by the authors is biochemically characterized by a significant increase in "T3" and decreased "T4" concentrations. This result coincides with that mentioned by Gray et al. (1985) and Furuoka et al., (1997) who stated that in cases suffering from diffuse hyperplastic goiter, the serum "T4" concentrations were lower than "T3" concentrations resulting in lower T4/T3 ratio. In addition, as the secretory capacity of thyroid gland is reduced in early hypothyroidism, "TSH" secretion increases and stimulates the remaining thyroid follicles to preferentially secrete "T3". Therefore, serum "T3" concentrations decreases late in hypothyroidism. The registered "T4" and "T3" concentrations in the sera of the examined animals contradicts the results of Dybdal, (1996) who recorded that the diagnosis of hypothyroidism is commonly based on low serum concentrations of "T4" and "T3".

Ten days post-thyroidectomy, the serum concentrations of "T3" was significantly increased and "TSH" was significantly decreased. The possible explanation is that the deiodination of "T4" to form "T3" is catalysed by thyroxine-5- deiodinase which is activated due to thyroidectomy. The decrease of "TSH" may be due to significant increase of the thyroid hormones (Li et al., 1986).

Serum protein bound iodine (PBI) of mother dams and their affected kids in the present study was lower in comparison with control animals.

This confirms the pervious observation of Gray et al. (1985) Capen, (1995) and Bires et al. (1996) who stated that PBI fraction is considered to be of greater clinical significance than the total blood iodine and PBI fluctuations are regarded as reflecting thyroid activity.

Of interest was the observation of resolution of clinical signs of disease especially enlargement of thyroid gland within 14-days follow-up period. The possible explanation for resolution of thyroid enlargement post-thyroidectomy and the increase in "T3" and "PBI" in addition to the return of "T4" to its normal level inspite of low "TSH" is not clear. However, it could be due to the transient decrease of "T3" and "T4" levels induced by the hemithyroidectomy which may stimulate more production of "TSH" resulting in enhancement of endocytosis of colloid in thyroid follicles, followed by resolution of thyroid gland enlargement (Capen, 1995).

Concerning the minerals profile of all affected kids and their dams in this study had normal serum calcium and phosphorus concentration except slight hypocalcaemia post operation, and this in agreement with the findings of Carver et al (1995) and Erdman & Plante (1999).

A significant increase of serum magnesium value, was observed in the hypothyroid kids and their dams when compared with euthyroid state. Ten days post thyroidectomy it was decreased slightly but still higher than control. This was in agreement with those reported in many studies (Rizek et al 1965) Jones et al., (1966) and Simsek et al., 1997,a). On the other hand, Simsek et al., (1997,b) reported lower values for magnesium concentration in both plasma and erythrocytes of hypothyroid state while Doleve et al. (1988) found no difference compared to the euthyroid state. It is generally agreed that thyroid hormones increase renal plasma flow, glomerular filteration rate, and thus, urinary Mg excretion. Also thyroid hormones are reported to stimulate the renin-aldosterone system (Ogihera et al., 1973 and Montiel et al., 1984). Urinary magnesium excretion is known to increase and serum Mg concentration decrease under conditions that activate the rennin-aldosterone system (Horton and Biglieri, 1972).

Concerning trace elements, it was interesting in this study to comment on the role of iodine concenteration in the ration in relation to iodine concenteration in the serum on the occurrence of hypothyroidism, but it was difficult to obtain dependable figures of the quantities of the ration fed daily and therefore, no reliable estimate could be made of the daily iodine intake.

However, copper concentration was found to be significantly increased in the affected kids and their dams. Ten days post thyroidectomy, serum copper values decreased but still higher than control levels. These findings agreed with Mocan et al. (1989) who reported significant increase in serum copper concentrations in a goitrous compared with a control state and found that serum copper increased as the size of the gland increased. Erkilic et al., (1996), observed that mean serum ceruloplasmine (Protein Containing-Copper) of hyperthyroid patients was greater than that of controls. These findings may indicate a direct effect of thyroid hormones on ceruloplasmin metabolism. However, Lukaski et al., (1995) recorded significant depression ($P < 0.05$) in plasma thyroxine concentrations in severity cu-deficient compared with moderately cu-deficient and cu-adequate animals.

Serum zinc levels were significantly lowered in both diseased kids and dams compard to control groups. Ten days post operation, serum zinc still lower than control kids but not significantly. These findings were in accordance with Simsek et al. (1997a), Saner et al. (1992) and Doleve et al. (1988) who reported significantly lowered values for serum zinc concentration in hypothyroid state when compared with controls. On the other hand Aihara et al. (1984) and Mocan et al. (1989) reported no significant difference in plasma zinc concenterations between patients with hypothyroidism and control subjects. Zinc turnover and utilization were shown to be significantly arrested in rats made hypothyroid by ^{131}I treatment (Yadav et al., 1980). Tuniguchi et al., (1978) suggested that thyroxin inhibits the synthesis of carbonic anhydrase B, the most abundant zinc metalo-enzyme in erythrocyte. Yoshida et al (1990), on the basis of a negative correlation between "T4" and erythrocyte zinc values in hypothyroidism, suggested that erythrocyte zinc values reflects a patient's mean thyroid hormone level over the preceding several months.

Concerning cobalt concentration, a significant decrease was recorded in the affected kids and their dams as well as post thyroidectomy. These findings agree with Leathem (1966); Underwood (1977) and Mgongo, et al. (1981) who reported hyperplasia of thyroid gland in cobalt and Vit B12 deficient animals. Cobalt is required for Vit B12 synthesis which in turn is needed for the synthesis of thyroid hormones and for energy metabolism (Blokhima, 1970 & Underwood, 1975).

As well as cobalt, selenium concentration showed the same trend with significant decrease in affected kids and their dams as well as post operation. These findings are agreed with those reported by Abdel Gadir and Adam (1999) who recorded significant reduction in concentration of selenium in serum of male goat kids fed dietery millet (goitrogenesis) compared with control. The relationship between iodine and selenium has been investigated by Beckett et al. (1987) and Arthur et al (1988,1990). These authors found that selenium is needed for hepatic conversion of thyroxine (T4) to 3,3,5-triiodothyronine (T3) and that type I iodothyronine deiodinase, identified as a selenocysteine containing enzyme, catalyses deiodination of (T4) to biologically active thyroid hormone (T3) and thus plays an important role in thyroid hormone metabolism in rats and cattle.

In conclusion, a presented evidence to confirm the hypothesis that the homeostasis of magnesium, copper and zinc is altered during hypothyroidism. On the other hand, it was possible that deficiency of cobalt and selenium in dams may play a role to cause congenital goiter in their kids. Also it can be said that the hemithyroidectomy can occupy a therapeutic surgical goiter in goat kids.

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