

THE INFLUENCE OF SLEEP DEPRIVATION ON LEVELS
OF SERUM HORMONES IN HEALTHY CALVES
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M. DOSTÁL, BOHUMÍRA BÍLKOVÁ¹ J. VAŠKŮ, V. PAVLIČEK,
P. GUBA AND OLGA ŠOTOLOVÁ

Department of Pathological Physiology, Medical Faculty, J. E. Purkyně
University, 662 43 Brno, ¹Department of Nuclear Medicine,
District Institute of National Health, 669 00 Znojmo

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The influence of 24 h of sleep deprivation on the blood serum concentration of aldosterone, thyrotropine, triiodothyronine, and thyroxine was studied in healthy calves. In the experiment, 14 calves (Bohemian Pied x Holstein) aged 3 months with mean body mass of 85 kg were used. Blood samples were collected from the v. jugularis externa. The concentration of hormones was measured using RIA.

A sleep deprivation of 24 h led to a statistically significant ($P < 0.05$) increase of aldosterone and thyrotropine levels and to a significant ($P < 0.05$) decrease of triiodothyronine. The level of thyroxine and the triiodothyronine/thyroxine ratio were not changed significantly.

Calf, stress, aldosterone, TSH, T_3 and T_4 .

The loss of afferent nervous stimulation from mechanoreceptors of the heart ventricles as a consequence of the implantation of a total artificial heart leads to changes of both neural as well as humoral feedback control (Imachi et al. 1983; Vašků et al. 1987). Changes have been described in the levels of thyroid hormones, aldosterone, renin, catecholamines, and vasopressin (Bücherl et al. 1979; Imachi et al. 1983; Stanley et al. 1976; Vašků et al. 1987; Webster et al. 1978). Both the specific effects of the total artificial heart as well as non-specific stress reaction play a role in the changes of some hormone levels (Stanley et al. 1976; Vašků 1965; Webster et al. 1976). To determine the influence of the latter factor this preliminary study undertook an investigation of the influence of a 24-h sleep deprivation on the serum level of selected hormones. Another aim of this study was to determine physiological values of thyroid gland hormones in calves used in total artificial heart experiments.

Materials and Methods

The blood for measurement of aldosterone, thyrotropine - TSH, triiodothyronine - T_3 and thyroxine - T_4 concentration was taken from 14 clinically healthy calves (6 females, 8 males). The animals (Bohemian Pied x Holstein) had a mean body mass of 85 kg; their age was 3 months. The calves were restrained individually in stalls of a common calf-shed. The temperature in the barn at the time of sampling was 25 °C; blood samples were collected between 10-11 a.m. daily, i.e. 2-3 h after feeding. The first sampling was the control, the second collected 24 h after sleep deprivation, was the experimental.

Sleep deprivation was induced by causing the calves to get up each hour. Blood was drawn by aspiration from a direct venipuncture of the v. jugularis externa, using a needle and a plastic syringe. The blood was transferred into glass test tubes and centrifuged at 2,500 r.p.m. for 20 minutes. The serum samples were placed into glass test tubes and stored at -18 °C pending analysis (within 6 weeks).

Aldosterone concentration was measured using methods described in our previous study (D o s t á l et al. 1985). Thyroxine (T_4), triiodothyronine (T_3) and thyrotropine (TSH) were measured using classical RIA methods modified for laboratory requirements of the Department of Nuclear Medicine, the District Institute of National Health at Znojmo. The TSH concentration was determined using a specific antibody Calbiochem - Boehringer Lot No. 142107; the hormone was labelled by chloramin iodation using NaJ^{125} made by Amersham (England) The separation of a binding fraction was carried out using another antibody - Riagar. The sensitivity of the method for TSH measurement was 1.25 mU.l^{-1} , variation coefficient 13.5 %.

The T_3 determination was carried out using a specific antibody from the Research Institute of Endocrinology at Ľubochňa, radioligand from ÚRVJT Košice. Another antibody - Riagar from Bioveta Ivanovice na Hané - was used for separation of the binding fraction. The sensitivity of the method was 0.2 nmol.l^{-1} , variation coefficient 9.2 %.

To measure the T_4 concentration, a specific antibody was employed as provided by the Institute of Experimental Endocrinology, Slovak Academy of Science in Bratislava, commercial radioligand from ÚRVJT Košice; the separation of a binding fraction was carried out with polyethylenglycol Mr 6,000. The sensitivity of the method was 3.4 nmol.l^{-1} , variation coefficient 6.8 %.

The T_3/T_4 ratio was calculated as the ratio of T_3 and T_4 levels in the plasma in nmol.l^{-1} and multiplied by 10^3 as reported by S c h e i - d e g g e r et al.(1984).

The means and standard deviations of the values were calculated for each experimental animal. Student's t-test for analysis of means was used for comparison of pairs. The P values of less than 0.05 were considered significant (R e i s e n a u e r 1970).

Results

The mean values, standard deviations, and standard errors of the means for the hormones studied, before and after 24 h of sleep deprivation are presented in Table 1. After sleep deprivation, aldosterone and TSH were elevated by 184 % and 22 %, respectively. The concentration of T_3 was

Table 1
Serum hormones levels before and after 24 hrs
sleep deprivation (n = 14)

quantity		before	after	t-test
ALDO (pmol/l)	\bar{x}	33.26	94.35	
	\pm S.D.	20.69	63.55	P < 0.05
	\pm SEM	5.53	16.98	
TSH (mU/l)	\bar{x}	2.31	2.81	
	\pm S.D.	0.57	0.63	P < 0.05
	\pm SEM	0.15	0.17	
T ₃ (nmol/l)	\bar{x}	1.99	1.68	
	\pm S.D.	0.35	0.34	P < 0.05
	\pm SEM	0.09	0.09	
T ₄ (nmol/l)	\bar{x}	109.56	104.16	
	\pm S.D.	29.74	20.39	N.S.
	\pm SEM	7.95	5.45	
S-T ₃ /S-T ₄ x 10 ³	\bar{x}	18.1	16.1	
	\pm S.D.	1.8	6.6	N.S.
	\pm SEM	1.3	6.5	

decreased by 16 %, that of T₄ by 5 % and their ratio (T₃/T₄) was decreased by 11 %. The increase of aldosterone and TSH levels and the decrease of T₃ were significant (P<0.05) with regard to controls (Fig. 1).

Discussion

The results obtained from control and experimental samples are within the physiological values of these hormones which have been reported for man: aldosterone up to 400 pmol.l⁻¹ in a resting position after a few hours rest), TSH up to 5 mU l⁻¹, T₃ 1.5 - 3.5 nmol l⁻¹, T₄ 60 - 160 nmol l⁻¹. The

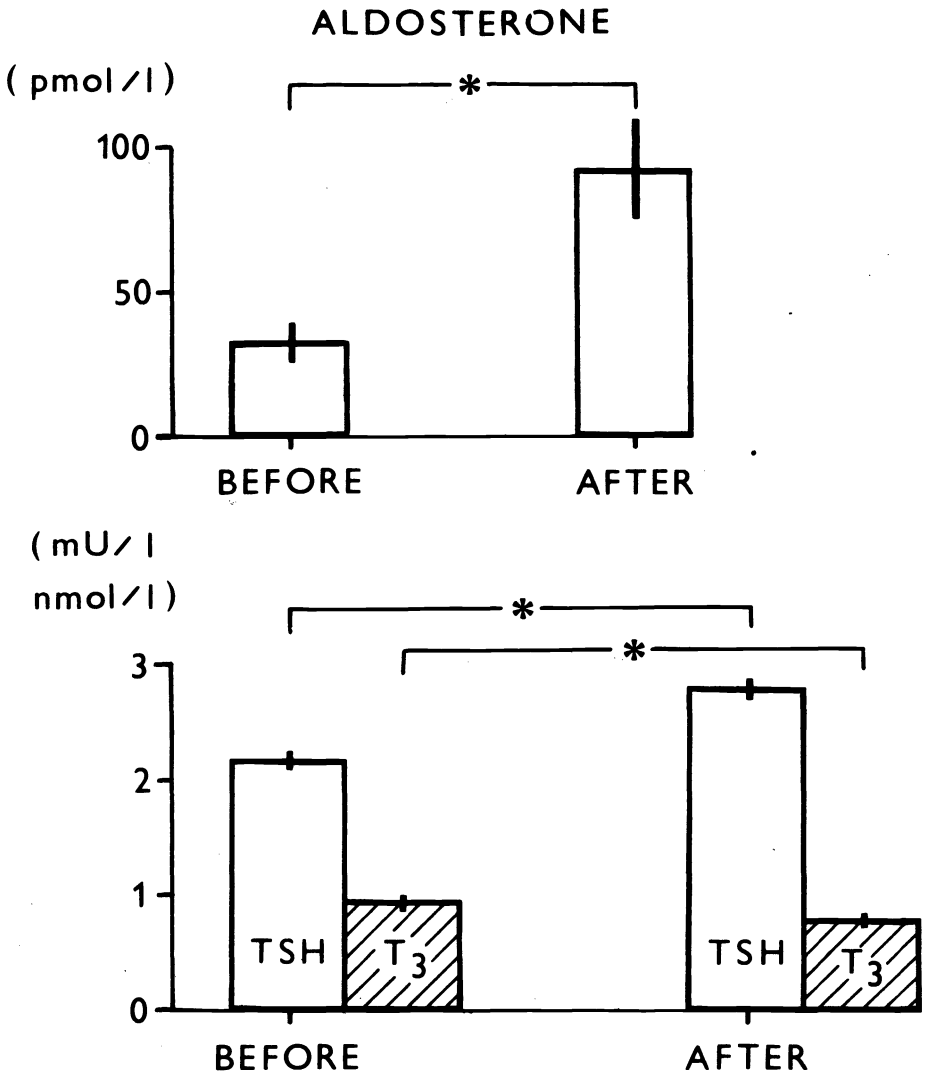


Fig. 1. Serum aldosterone (pmol.l^{-1}), thyrotropine (TSH, mU.l^{-1}) and triiodothyronine (nmol.l^{-1}) levels before and after sleep deprivation. The values are presented as means \pm S.E.M.; * = $P < 0.05$

ratio of T_3/T_4 is reported to be within a range of 12-32 in adult healthy persons (both men and women) (E r f u r t h and H e d n e r 1986).

The levels of aldosterone were significantly decreased in the present group of calves when compared with our previous observations. In calves of the same age, body mass, confinement and feeding procedures, employed in a previous study, mean values of aldosterone of 85.6 - 26.9 pmol.l⁻¹ (D o s t á l et al. 1985). However, that experiment was conducted in a different season (January 1984), whereas the present study was carried out in August 1986. These differences show the importance to consider the influence of season on plasma hormone concentrations.

Increased levels of aldosterone after 24-hours sleep deprivation can be explained by a neurosecretory response of the hypothalamus. After the release of corticotropin-releasing hormone (corticoliberin) an increase of adrenocorticotrophic hormone (ACTH) occurs which stimulates directly the cells of the zona glomerulosa of the adrenal gland, resulting in an increase in the plasma level of aldosterone (B u r c h f i e l d 1985; V a š k ů 1965).

The data of the TSH levels as a sequel to stress are in conflict. Reports of its increased secretion are few; most describe it as being inhibited (S c h r e i b e r 1985). The differing data may reflect differences in the experimental design, especially the intensity of stress, stimulus and the reaction of the individual or the species.

Even the data of the response of the thyroid hormones (T_3 , T_4) on acute stress are also differing. Permanent physical stress connected with insufficient dietary energy intake leads to the drop of both T_3 and T_4 with simultaneous shift to the deiodination of thyroxine in tissues (S c h r e i b e r 1985). Sleep deprivation of our experimental animals was also connected with greater physical activity (longer periods of standing, moving), while the amount of food offered was not changed.

The slight increase of TSH and decrease of T_3 and T_4 found in the present study is in agreement with data published of these levels in human patients suffering burn

injury. The level of T_3 was decreased substantially more than that of T_4 . Our study recorded a non-significant decrease was caused by the decrease of T_3 and T_4 or it is a response to stimulating influence of thyroid releasing hormone (TRH), released from the hypothalamus in response to stress reaction (B u r c h f i e l d 1985; S c h r e i b e r 1985).

Regarding hormones of the thyroid gland and TSH, no data for calves of identical age and body mass category have been found in the available literature. Therefore, present data may serve as reference values for further research of hormones of animals with total artificial heart implanted and surviving for a long time. Further experimentation is needed of the link between stress and thyroid gland function.

Vliv spánkové deprivace na koncentrace hormonů v krevním séru zdravých telat (metodické sdělení)

Byl sledován vliv 24hodinové spánkové deprivace na hladiny některých hormonů v krevním séru (aldosteron, tyrotropin, trijodtyronin, tyroxin). Studie byla provedena u 14 telat (české strakaté x Holsteinské, věk 3 měsíce, průměrná hmotnost 85 kg), která byla ustájena ve společném teletníku. Krev pro stanovení hormonů byla odebírána punkcí v. jugularis externa. Koncentrace hormonů byly stanovovány RIA metodami.

Bylo zjištěno, že 24hodinová spánková deprivace vede ke statisticky významnému zvýšení hladin aldosteronu a tyrotropinu a ke snížení trijodtyroninu. Hladina tyroxinu a poměr trijodtyronin/tyroxin se významně neměnily.

Влияние депривации сна на уровни гормонов в кровяной сыворотке здоровых телят (методическое сообщение)

Авторы изучали влияние суточной депривации сна на уровни некоторых гормонов в кровяной сыворотке

(альдостерон, тиротропин, трийодтиродин, тироксин). Исследование проводили у 14 телят чешской пестрой породы, скрещенной с голштейнской породой (возраст 3 месяца, средняя масса 85 кг), содержащихся в совместном телятнике. Взятие крови для определения гормонов проводили пункцией наружной яремной вены. Уровни гормонов определяли методами РИА.

Было установлено, что суточная депривация сна приводит к статистически значимому повышению уровня альдостерона и тиротропина и понижению трийодтиронина. Уровень тироквина и соотношение трийодтиронин/тироксин существенно не менялись.

References

- BÜCHERL, E.S. - AFFELD, K. - BAER, P. - CLEVERT, H.D. - FRANK, J. - GERLACH, K. - GROSSE-SIESTRUP, C. - HENNIG, E. - KEILBACH, H. - KRAUTZBERGER, W. - KUHLMANN, V. - LEMM, W. - MOHNHAUPT, A. - RENNEKAP, F. - UNGER, V. - WIEDEMANN, H. - ZARTNACK, P.: Total artificial heart replacement. *Int. J. Artif. Organs*, 2, 1979: 141 - 152.
- BURCHFIELD, S.R.: *Stress. Psychological and Physiological Interactions*. Hemisphere Publishing Corporation, Washington, New York, London 1985, 1st ed., pp. 399.
- DOSTÁL, M. - BÍLKOVÁ, B. - VAŠKŮ, J. - GUBA, P. - ŠOTÁKOVÁ, E.: Hladiny aldosteronu v séru zdravých telat a koz (předběžné sdělení). *Čs. fyziol.*, 34, 1985: 377 - 380.
- DOSTÁL, M. - VAŠKŮ, J. - BÍLKOVÁ, B.: Serum aldosterone concentrations after total artificial heart (TAH) implantation. *J. Steroid Biochem.*, 25, supplement, 1986: 111 s.
- ERFURTH, E.M. - HEDNER, P.: Thyroid hormone metabolism in thyroid disease as reflected by ratio of serum triiodothyronine to thyroxine. *J. Endocrinol. Invest.*, 9, 1986: 407 - 412.
- IMACHI, K. - FUJIMASA, I. - MIYAMOTO, A. - TAKIDO, N. - NAKAJIMA, M. - INOU, N. - MOTOMURA, K. - MABUCHI, K. - KOUNO, A. - ONO, T. - ATSUMI, K.: Development of control method of total artificial heart (TAH). A trial of neural control with electric stimulation and its effects. *Jpn. J. Artif. Organs*, 12, 1983: 24 - 27.
- REISENAUER, R.: *Metody matematické statistiky a jejich aplikace*. Praha, Práce + SNTL, 1970, pp. 1 - 293.
- SCHEIDEGGER, K. - O'CONNELL, M. - ROBBINS, D.C. - DANFORTH, E.Jr.: Effects of chronic beta-receptor stimulation on sympathetic nervous system activity, energy expenditure, and thyroid hormones. *J. Clin. Endocrinol. Metab.*, 58, 1984: 895.
- SCHREIBER, V.: *Stres*. Avicenum, Praha 1985, 1. vyd., pp. 81 - 82, 221 - 223, 274 - 281.
- STANLEY, T.H. - LIU, W.S. - GENTRY, S. - KENNARD, L. - ISERN-AMARAI, J. - OLSEN, D.B. - LUNN, J.: Blood and urine catecholamine concentrations after implantation of artificial heart. *J. Thoracic and Cardiovasc. Surg.*, 71, 1976: 704 - 710.

- VAŠKŮ, J.: Kapitoly z všeobecné patologické fyziologie. SNP, Praha 1965, pp. 234.
- VAŠKŮ, J. - ČERNÝ, J. - DOSTÁL, M. - GUBA, P. - VAŠKŮ, Jan - URBÁNEK, P. VASKŮ, A. - DOLEŽEL, S.: Neurohumoral aspects of total artificial heart . International Meeting on Heart Transplantation, Total Artificial Heart and Assist Devices. Programme and Abstracts, 1987: 43.
- WEBSTER, L.R. - STANLEY, T.H. - JARVIK, R. - PHILBIN, D. - KOLFF, W.J.: Plasma cortisol and antidiuretic hormone concentration after artificial heart implantation. Trans. Am. Soc. Artif. Inter. Organs, 24, 1978: 305 - 308.