Acta Dermatovener (Stockholm) 54: 49–52, 1974

TRACE ELEMENTS WITH SUSPECTED AND HITHERTO UNKNOWN BIOLOGICAL FUNCTION IN NORMAL AND PSORIATIC EPIDERMIS

Lars Molin and Per Olov Wester

From the Department of Dermatology, Karolinska sjukhuset, Stockholm and the Department of Internal Medicine, Serafimerlasarettet, Stockholm, Sweden

Abstract. By means of neutron activation analysis, trace elements of suspected biological function (bromium, cadmium, chromium, molybdenum, rubidium and selenium) and hitherto unknown biological function (arsenic, gold, cesium, mercury, lanthanum, antimony, scandium, samarium and wolfram) have been determined with respect to the content in normal epidermis and in epidermis from untreated psoriatic lesions as well as uninvolved epidermis from subjects suffering from psoriasis.

There is a lower content of molybdenum, bromium and lanthanum in the untreated psoriatic epidermis than in normal and unaffected psoriatic epidermis. No difference is shown between the content of normal and unaffected psoriatic epidermis. As regards the other trace elements studied, no difference between normal and psoriatic epidermis is recorded.

The loss of cadmium, selenium, antimony, lanthanum and mercury via desquamation cannot be overlooked in balance studies.

In earlier papers we have reported on the epidermal content of trace elements of well known biological function in normal and psoriatic skin (4, 5). Differences in the concentration of cobalt and iron have thus been demonstrated in epidermis in untreated psoriatic skin which probably reflect the altered enzymatic activity in the psoriatic skin.

Several of the trace elements classified as being of suspected or hitherto unknown biological function for the human metabolism have also been shown to have an influence on various enzymatic processes, either being an essential part of the enzyme molecule or acting as catalysts or inhibitors.

The aim of the present study is to determine the epidermal content of the following trace elements of suspected biological function: bromium (Br), cadmium (Cd), chromium (Cr), molybdenum (Mo), rubidium (Rb), and selenium (Se), and the following of hitherto unknown biological function: arsenic (As), gold (Au), cesium (Cs), mercury (Hg), lanthanum (La), antimony (Sb), scandium (Sc), samarium (Sm), and wolfram (W).

The highly sensitive neutron activation analysis technique has been used which gives accurate figures for the epidermal content, thus allowing estimations of the role of skin desquamation in balance studies.

MATERIAL AND METHODS

Specimens of epidermis were obtained from 14 males, of whom 9 were suffering from psoriasis (age range from 20 to 59 years, mean age 46 years), and 5 were without signs of any skin disorder (age range from 19 to 57 years, mean age 33 years).

All specimens were obtained from the trunk, thus avoiding variations in the content of the elements in different regions of the body surface. No anaesthesia was used.

Separation of epidermis from dermis was performed using a suction blister method. The details of the separation and the method for the neutron activation analysis technique have been previously described (4).

The results were analysed statistically by analysis of variance.

RESULTS

The mean dry weight as a percentage of the wet weight for normal epidermis is $17.5 \pm 2.3\%$, for psoriatic unchanged epidermis $17.1 \pm 2.2\%$, and for psoriatic changed epidermis $24.5 \pm 3.1\%$.

The epidermal content of the studied elements in normal skin and in untreated psoriatic lesions as well as uninvolved skin from the subjects suffering from psoriasis is shown in Table I (ele-

Table I. *Trace elements with suspected biological function (μg/g dry weight)*

	Normal	Psoriatic uninvolved	Psoriatic involved
Bromium (Br)			
n	5	4	10
Mean ± S.D.	45.9 ± 36.8	23.6 ± 14.7	16.8 ± 10.9
Median	35.5	18.9	11.7
Range	16.0–107.2	12.1–44.4	4.7–34.4
Cadmium (Cd)			
n	5	5	6
Mean ± S.D.	0.096 ± 0.067	0.082 ± 0.030	0.042 ± 0.031
Median	0.10	0.10	0.035
Range	0.02–0.20	0.03–0.10	0.01–0.04
Cromium (Cr)			
n	2	3	3
Mean	1.20	0.97	1.43
Range	0.7–1.7	0.5–1.5	0.1–3.2
Molybdenum (Mo)			
n	5	5	10
Mean ± S.D.	1.70 ± 0.76	1.27 ± 0.26	0.29 ± 0.15
Median	1.7	1.4	0.23
Range	0.6–2.5	0.9–1.54	0.1–0.5
Rubidium (Rb)			
n	5	4	10
Mean ± S.D.	8.32 ± 3.68	9.98 ± 4.78	8.42 ± 4.96
Median	7.3	9.4	6.7
Range	4.6–13.0	4.8–15.9	3.2–19.4
Selenium (Se)			
n	5	4	10
Mean ± S.D.	1.18 ± 0.58	0.90 ± 0.47	1.18 ± 0.23
Median	1.2	0.9	1.2
Range	0.3–1.7	0.3–1.4	0.9–1.6

ments with suspected biological function) and in Table II (elements with hitherto unknown biological function).

There is a highly significantly lower content of molybdenum in untreated psoriatic epidermis than in normal epidermis and uninvolved psoriatic epidermis ($F = 54.136$, $p < 0.001$).

A lower content is also found as regards bromium in untreated psoriatic epidermis as compared with normal and uninvolved psoriatic epidermis ($F = 7.230$, $0.05 > p > 0.01$).

There is a not significantly lower level of cadmium in psoriatic untreated epidermis as compared with normal and uninvolved psoriatic epidermis ($F = 4.435$, $0.10 > p > 0.05$).

No difference was recorded as regards the content of cadmium, chromium, rubidium or selenium.

The content of lanthanum is found to be almost significantly lower in untreated psoriatic epidermis than in normal or uninvolved epidermis ($F = 4.741$, $0.05 > p > 0.01$).

Among the other elements with hitherto unknown biological function, no significant difference was noted in the content of epidermis from normal and psoriatic skin.

DISCUSSION

Tipton & Cook (8), when using spectrographic methods, could detect molybdenum in only 2 out of 22 investigated samples of normal whole skin but could not find cadmium in any of them. They proposed the content of whole skin to be less than 0.08 μg/g dry weight for molybdenum and < 1 μg/g dry weight for cadmium.

The present study gives cadmium concentration values for normal epidermis far beyond the upper limit proposed by Tipton & Cook for whole skin (8).

On the other hand the normal epidermal molybdenum content found in the present study is much higher than the upper limit proposed by Tipton & Cook for whole skin (8).

Chromium was only determined in two samples of normal epidermis in the present study. The values found are, however, in agreement with the figures given by Tipton & Cook for the whole skin content of chromium (8).

As far as the authors are aware there is no report on determination of the content of bromium, rubidium, or selenium in normal skin.

The present study has given a significantly lower content of molybdenum in untreated psoriatic epidermis than in normal and uninvolved psoriatic epidermis.

Molybdenum is known to be a part of the enzyme xanthine oxidase (2). However, xanthine oxidase seems not to have been found in human skin (1). The significance of the finding of lower content of molybdenum in psoriatic epidermis is not yet possible to evaluate.

It has been shown that selenium has great affinity for sulfhydryl compounds and cysteine, and it is likely that selenium enters into a chemical combination with keratin (7). The content of selenium was, however, the same in the untreated psoriatic epidermis as in the normal and the uninvolved psoriatic epidermis.

Table II. *Trace elements without known biological function (μg/g dry weight)*

	Normal	Psoriatic uninvolved	Psoriatic involved
Arsenic (As)			
n	5	5	10
Mean ± S.D.	0.23 ± 0.21	0.13 ± 0.07	0.09 ± 0.06
Median	0.1	0.1	0.08
Range	0.09–0.5	0.04–0.2	0.03–0.2
Gold (Au)			
n	5	5	10
Mean ± S.D.	0.0029 ± 0.0024	0.0026 ± 0.0013	0.0016 ± 0.0021
Median	0.002	0.002	0.0006
Range	0.0008–0.006	0.001–0.004	0.0001–0.006
Cesium (Cs)			
n	1	2	6
Mean ± S.D.			0.041 ± 0.029
Median			0.03
Range	0.1	0.1–0.2	0.006–0.07
Mercury (Hg)			
n	5	5	10
Mean ± S.D.	0.078 ± 0.019	0.122 ± 0.045	0.078 ± 0.016
Median	0.08	0.10	0.08
Range	0.05–0.10	0.09–0.20	0.05–0.10
Lanthanum (La)			
n	5	5	10
Mean ± S.D.	0.072 ± 0.017	0.070 ± 0.017	0.031 ± 0.017
Median	0.074	0.069	0.029
Range	0.054–0.094	0.014–0.118	0.009–0.049
Antimony (Sb)			
n	5	5	10
Mean ± S.D.	0.22 ± 0.11	0.22 ± 0.12	0.14 ± 0.11
Median	0.2	0.2	0.1
Range	0.09–0.4	0.08–0.4	0.03–0.4
Scandium (Sc)			
n	4	3	9
Mean ± S.D.	0.0011 ± 0.0012	0.0015 ± 0.0014	0.00098 ± 0.00065
Median	0.0005	0.001	0.001
Range	0.0004–0.003	0.0004–0.003	0.0004–0.002
Samarium (Sm)			
n	4	5	5
Mean ± S.D.	0.070 ± 0.038	0.054 ± 0.029	0.042 ± 0.027
Median	0.08	0.06	0.03
Range	0.02–0.1	0.03–0.3	0.02–0.08
Wolfram (W)			
n	5	5	10
Mean ± S.D.	0.16 ± 0.09	0.20 ± 0.18	0.14 ± 0.11
Median	0.1	0.2	0.1
Range	0.1–0.3	0.05–0.2	0.03–0.3

Approximatively 0.5 to 1 g of normal epidermis is desquamated per day (7). The average loss per day via desquamation in normal conditions is calculated to be about 20–35 μg bromium, 0.05–0.1 μg cadmium, 0.8–1.5 μg molybdenum, 5–10 μg rubidium, and 0.5–1 μg selenium which are all negligible as sources of error in balance studies.

In psoriatic untreated lesions the epidermal turnover rate is increased five to six times (6). The loss of selenium per day via desquamation

in untreated widespread scaling psoriasis can be calculated to rise up to 7 μg if the whole body surface is involved and that of cadmium up to 0.2 μg which is about one-fourth and one-tenth of the normal urinary excretion, respectively (10). The loss via desquamation calculated for the other three elements studied is still negligible even if the whole body surface is involved in scaling psoriasis.

Little if any information seems to be given in the literature concerning the skin content of most of the trace elements of hitherto unknown biological function which are investigated in the present study.

Tipton & Cook (8) detected gold in 4 out of 22 investigated normal whole skin samples and have calculated the median value of the gold content to be less than 0.2 μg/g dry weight. The figures for gold content in normal epidermis in the present study are far below the values given by Tipton & Cook for normal whole skin (8).

Recently Frithz (3) has published results of mercury determination in two samples of normal whole skin which are of the same magnitude as the mercury content of normal epidermis found in the present study.

Mercury is a highly volatile element and this circumstance often causes analytical difficulties. The analytical process used in the present study includes a drying step of the biological material, in which there exists a possibility of mercury losses due to volatilization. This source of error has been tested for mercury in heart tissue and found to be less than 15% (9). No such testing has been done for epidermis. Thus it cannot be excluded that the figures for the epidermal mercury content found in the present study may be too low.

Calculations of the daily loss via desquamation in normal conditions have been made for arsenic, mercury, lanthanum, antimony, scandium, and wolfram. The normal daily loss of antimony, lanthanum and mercury cannot be overlooked in balance studies, as it may reach as high as one-seventh, one-tenth and one-fourth of the normal urinary excretion, respectively (10). Corresponding calculations have not been made for gold and samarium because of the well known wide range of the concentration figures (9), nor have they been made for cesium because of the low number of determinations.

If the increased epidermal cell turnover in psoriasis is taken into account, the daily loss via desquamation in subjects whose whole body surface is involved by scaling psoriasis may reach as high as half the normal daily urinary excretion for antimony and lanthanum and one-third of the normal urinary excretion for mercury (10).

ACKNOWLEDGEMENTS

This investigation was supported by grants from Edvard Welanders Foundation and Karolinska Institutet.

REFERENCES

1. Barry, G., Bunbery, F. & Kennaway, E. L.: The effect of arsenic upon some oxidation-reduction systems. Biochem J *22:* 1102, 1928.
2. DeRenzo, E. C.: Chemistry and biochemistry of xanthine oxidase. Advances Enzym *17:* 293, 1956.
3. Frithz, A.: Cellular changes in the psoriatic epidermis. IX. Neutron activation analysis of mercury in patients topically treated with ammonium mercuric chloride. Acta Dermatovener (Stockholm) *50:* 345, 1970.
4. Molin, L. & Wester, P. O.: Iron content in normal and psoriatic epidermis. Acta Dermatovener (Stockholm) *53:* 473, 1973.
5. — Cobalt, copper and zinc in normal and psoriatic epidermis. Acta Dermatovener (Stockholm) *53:* 477, 1973.
6. Rothberg, S., Crounse, R. G. & Lee, J. L.: Glycine-C^{14} incorporation into the proteins of normal stratum corneum and the abnormal stratum corneum of psoriasis. J Invest Dermatol *37:* 497, 1961.
7. Rothman, S.: Physiology and Biochemistry of the Skin. University of Chicago Press, Chicago, 1954.
8. Tipton, I. H. & Cook, M. J.: Trace elements in human tissue. Part II. Adult subjects from the United States. Health Phys *9:* 103, 1963.
9. Wester, P. O.: Concentration of 24 trace elements in human heart tissue determined by neutron activation analysis. Scand J Clin Lab Invest *17:* 357, 1965.
10. — Trace elements in serum and urine from hypertensive patients before and during treatment with chlorthalidone. Acta Med Scand. Unpublished data.

Received April 3, 1973

L. Molin, M.D.
Department of Dermatology
Regionsjukhuset
S-581 85 Linköping
Sweden