Acta Derm Venereol 2003; 83: 10–13

Taylor & Francis
healthsciences

INVESTIGATIVE REPORT

Cutaneous Microdialysis of Uric Acid Level in the Dermis: Modification of *In vitro* Recovery

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Cutaneous microdialysis is a new tool for direct sampling and real-time monitoring in dermatological research. However, its use in general laboratory practice poses several problems, one of which is determination of the relative recovery of the target material. Uric acid, one of the major antioxidants in the skin, was analysed using cutaneous microdialysis in 11 healthy subjects. Two methods for *in vitro* recovery were adopted, one in which a standard solution of uric acid was used and another in which serum was used. Although differences between the two methods were found, it is suggested that establishing the *in vitro* recovery using serum might be a simple approach for microdialysis. *Key words: antioxidants; in vitro recovery; microdialysis; uric acid.*

(Accepted August 16, 2002.)

Acta Derm Venereol 2003; 83: 10–13.

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Cutaneous microdialysis has been established as a unique technique for assessing endogenous and exogenous materials in the skin (1). Many studies on percutaneous drug absorption and skin inflammation using cutaneous microdialysis have been published. Although the cutaneous microdialysis method has several merits for direct sampling and real-time monitoring, there are many technical problems in target material selection and requirements for delicate experimental conditions (2). In particular, determining the actual recovery of a substance has been one of the problems during the microdialysis procedure (3, 4). Therefore, a quantitative microdialysis experiment should be performed before the main study in almost all cases (5, 6).

The antioxidant defence mechanism in human skin has attracted considerable interest and been studied by many researchers, probably because of interest in an anti-ageing mechanism (7). Clinical trials, animal experiments and human tissue analyses have been major tools in such investigations. However, there are only few reports on antioxidant levels in the human epidermis and dermis (8, 9). Uric acid is considered to be a bifunctional material; is it a risk factor for coronary heart disease or is it a major antioxidant in human tissues (10)? Probably, because of this, less attention has been focused on uric acid than on antioxidants such as ascorbic acid, glutathione or vitamin-E. Recently, the redox cycle of antioxidants in humans has attracted more attention than each antioxidant concentration itself (11). In this article we report on the level of one of the non-enzymatic antioxidants, uric acid, in skin of healthy volunteers measured by cutaneous microdialysis.

One of the aims of the present study was to compare two methods for assessing the *in vitro* recovery of uric acid, which is an endogenous material and has some impediments to direct human administration. The other was to investigate the possibility of whether microdialysis could be used to quantify the antioxidant concentration in healthy human skin.

MATERIALS AND METHODS

Subjects

Eleven healthy male volunteers were enrolled in this study. They were divided into two groups according to age. Six subjects were in their 3rd decade (the young group), the others in their 8th (the aged group). None showed evidence of cardiac problems or a history of gout. All subjects provided informed consent. The Institutional Review Board, Seoul National University Hospital, approved the study conducted by the Department of Dermatology (Seoul, Korea).

Relative recovery

Relative recovery (RR) was determined in two ways. One was from a dialysate collection from a vial containing a standard uric acid solution. The other was from serum and was compared with a direct measurement of uric acid.

In vitro procedure for relative recovery: standard solution

Uric acid (2,4,6-trihydroxypurine; Sigma Chemical Co., St. Louis, USA) was used for the standard solutions in concentrations ranging from 2.5 to 20.0 μg/ml in diluted water in order to determine relative recovery. A microdialysis probe was placed in a vial containing uric acid solution with a known concentration. The standard solution was pre-warmed at 37°C on a heating block (Barnstead/Thermolyne, Iowa, USA). The microdialysis procedure was done in identical conditions (see below for details of the human study). All

 ISSN 0001-5555

procedures were performed in a light-shielded state in duplicate.

In vitro procedure for relative recovery: human serum

Four healthy male medical students, aged 24–27 years, were investigated. None had a history of cardiac disease or metabolic disorders, including gout. All had been checked for febrile conditions or intake of anti-inflammatory medication. Fasting venous blood samples were collected in two evacuated plain collection tubes (Beckton-Dickinson, USA) and stored in a light-shielded state for 1 h at room temperature. The total volume of blood was approximately 10–12 ml. The serum was collected from the coagulated blood by centrifugation (2,500 rpm at 4°C). Each serum sample was divided into six microcentrifuge tubes and immediately stored at −70°C. The microdialysis probe was placed in a vial containing serum. The microdialysis procedure and uric acid analysis were done under identical conditions as used for *in vitro* recovery with the standard solution and human experiments. All were performed in triplicate.

Microdialysis procedure

All procedures were performed in an environmentally controlled room at 26°C with 60% humidity. Three 2.5-cm-diameter circles were marked on the ventral side of the left forearm and separated at intervals of 5.0 cm. Topical anaesthetic cream, EMLA (Astra, Stockholm, Sweden), 5.0 g, was applied to the marked regions. Tegaderm (3M, Germany) was attached to the applied site for 2 h. The CMA/20 microdialysis probe, with a molecular weight cutoff of 20 Kd (CMA/Microdialysis AB, Stockholm, Sweden), was inserted into the forearm skin. The microdialysis system was perfused with isotonic normal saline at a rate of 5.0 μl/min. The tube was connected to the CMA100 microdialysis pump (CMA/Microdialysis AB) and the procedure was performed essentially as described previously (12). Dialysate samples were collected at 30-min intervals in a light-shield state and immediately stored at −70°C until analysed by high performance liquid chromatography (HPLC) analysis.

The depth of the inserted probe was evaluated by an ultrasound device (Dermascan C, Cortex Technology, Hadsund, Denmark). None experienced a febrile sensation during the examination.

Analysis of uric acid

The uric acid concentration in the dialysate was assayed using HPLC. Chromatographic separation was obtained with a Higgins Clipeus C18 5-μm column. A mobile phase was a mixture of monochloroacetic acid, sodium hydroxide and Na_2EDTA. Analysis was done at a flow rate of 1 ml/min. The peak detection was performed using a TOA amphorometric detector (TOA Electronics, USA).

Statistics

The statistical significance of the *in vitro* relative recovery of uric acid was tested with simple linear regression analysis. Student's *t*-test and the Mann-Whitney U-test were used to analyse the uric acid concentration *in vivo*. All statistical analyses were performed using a Microsoft Office Package and SPSS.

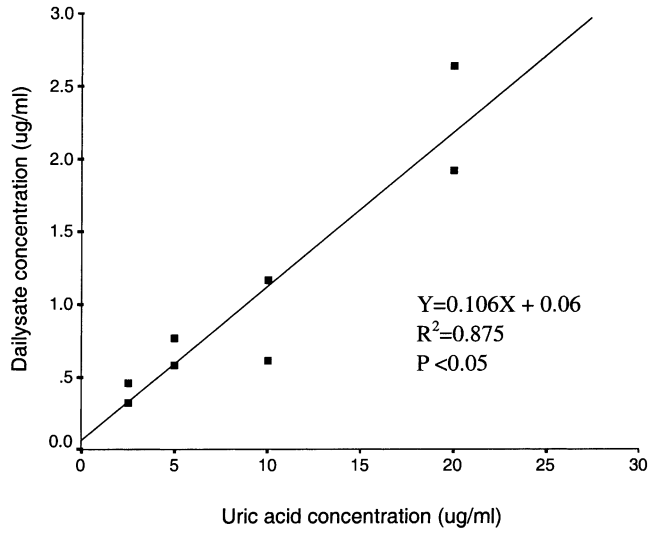

Fig. 1. In vitro relative recovery of uric acid.

RESULTS

Relative recovery of uric acid

Fig. 1 shows the dialysate concentrations from the standard uric acid solutions (2.5, 5.0, 10.0, 20.0 μg/ml). Linear regression demonstrated a significant correlation between the standard concentration level and the dialysate. *In vitro* recovery of uric acid using the standard solution at a perfusion rate of 5.0 μl/min was approximately 12.3±2.9% for the CMA/20 catheter.

Table I presents the concentration of uric acid from the sera and dialysate of four subjects. The normal uric acid level in the serum is known to be in this range (men 25–80 μg/ml, women 15–60 μg/ml) (13). *In vitro* recovery of uric acid from serum was approximately 10.1±1.2%. Linear regression analysis also showed a similar linearity compared to that of the standard uric acid solution, but it was not statistically significant ($Y = 0.06X + 1.81$, $R^2 = 0.867$, $p > 0.05$).

In vivo studies for uric acid

Table II indicates the dialysate and estimated uric acid levels using cutaneous microdialysis for the two methods for determining the relative recovery. In the

Table I. *In vitro recovery of uric acid using sera*

Subject (age)	Serum conc. (μg/ml)	Dialysate conc. (μg/ml)	Relative recovery (%)
1 (24)	36.0	4.3	11.9
2 (24)	59.3	5.8	9.7
3 (24)	59.3	5.7	9.6
4 (27)	50.3	4.6	9.2
Mean±SD	51.2±11.0	5.1±0.8	10.1±1.2

SD = standard deviation.

Table II. *Microdialysis data of uric acid from 11 subjects*

Subject (age)	Dialysate (μg/ml)	Tissue conc. 1[a] (μg/ml)	Tissue conc. 2[b] (μg/ml)
A (73)	2.1	16.6	20.3
B (70)	1.3	10.7	13.1
C (74)	1.2	10.0	12.3
D (75)	1.3	10.5	12.8
E (78)	2.4	19.4	23.7
F (29)	8.6	69.4	84.8
G (28)	3.6	29.4	36.0
H (25)	1.4	11.2	13.7
I (25)	2.8	22.9	27.9
J (30)	2.2	17.7	21.7
K (22)	2.3	18.9	23.1
Mean ± SD	2.7 ± 2.1	21.5 ± 17.0	26.3 ± 20.8

a = Estimated tissue concentration by relative recovery using standard solution.
b = Estimated tissue concentration by relative recovery using sera.

aged group, the mean level of uric acid was lower than that in the young group (13.4 ± 4.3 vs. 28.3 ± 21.0 with RR in standard solution, or 16.4 ± 5.2 vs. 34.5 ± 25.7 with RR in sera, μg/ml). However, no statistically significant difference in the uric acid concentration was found between the two groups.

DISCUSSION

The anti-ageing process has been a major interest to many researchers, including dermatologists. Although many studies have reported an interrelation among antioxidants, UV light, chronological ageing, vitamins and other factors, reports on the antioxidants themselves in the skin are uncommon (14). Since Shindo et al. (9) reported the level of enzymatic and non-enzymatic antioxidants in the epidermis and dermis of human and murine skin using biopsy specimens, some data relating ageing and antioxidants have been reported (15). However, they did not present the results from a direct or real-time sampling.

Microdialysis is regarded as a new sampling method for overcoming some limitations (1, 2) and several adaptations have been used in dermatology (12, 16–19). However, it has certain limits for further expanding into dermatological research, one of which is measuring the relative recovery (1–4, 19). Two methods were used for the direct testing of *in vitro* recovery modified from the method reported by Wennberg et al. (17). We found dissimilarity in the relative recovery measured by the two methods. It is believed that such results reflect the limitation of a direct application of *in vitro* relative recovery. Factors considered to have an influence on the experimental results include over time sampling, the metabolic state of the volunteer and the skin temperature. For a correct relative recovery determination using human serum, the microdialysis procedure and collection were maintained for 3 h in order to detect the effect of dilution of serum by running fluid or the depletion of uric acid in the serum. However, since no reliable variations among time intervals were found within 3 h (data not shown in this article), the influence of collection over a period could be excluded within the collecting time operated by the procedure. In addition, the volunteers were permitted to participate in this experiment only if they were in a healthy condition. All subjects who had consumed alcohol, antioxidants such as vitamin-C or E, metabolic disease and/or febrile conditions were therefore excluded from the microdialysis procedure. For that reason, an attempt was made to minimize any factors influencing the result of the cutaneous microdialysis, such as a change in the metabolic condition, for example skin temperature. Although no statistically reliable results were shown for either *in vitro* method, it is suggested that a relative recovery determination using serum should be considered for a new trial of a simple microdialysis procedure, particularly for some materials regarded to be harmful (20).

An attempt to investigate the association between uric acid and ageing was also made in this study. Although the differences in uric acid level between the young group and the aged group did not show statistical significance, the data indicated that the uric acid level was higher in the young group than in the aged group, as has been reported elsewhere (21). It is suggested that this difference should be interpreted by two mechanisms. One is the change in the constitution of the dermis with the ageing process. According to Gniadecka's explanation for dermal echogenicity (22), the chronological or photo-ageing process might result in a build-up in dermal water content, leading to structural alterations. These changes could induce the uric acid level to decrease with age. However, Rhie et al. (21) reported that the uric acid level was similar during both the photo-ageing and the natural ageing process. Therefore, more factors that differ with a constitutional change need to be investigated if the change in uric acid concentration is to be explained. The other explanation is the balance of uric acid during restoration of the antioxidant chain reaction. Recent hypotheses and reports have proposed that a new evaluation of the chain reaction of the antioxidants mechanism above the concentration itself be done (23, 24). Uric acid is considered to fill the role of an electron sink in the antioxidant redox cycle (11). We hypothesize that the levels of uric acid, α-tocopherol and ascorbic acid interact with one another for homeostasis. It is proposed that the uniform decrease in the level of these three antioxidants during photo-ageing and the natural ageing process supports this hypothesis.

Although more studies evaluating the relative recovery determination using serum and reducing the

inter- and intra-individual variations are needed. This approach may be a short way of making cutaneous microdialysis more useful in human studies.

ACKNOWLEDGEMENTS

This article was supported by a grant – the "Life Phenomena and Function Research Group Program (2002)" – from the Ministry of Science and Technology, and a research agreement with the Pacific Corporation. We thank Eun Kyoung Lee, for expert technical HPLC assistance. Ae Kyoung Woo and Mi Ran Kwon, subject arrangement and Dong Youn Lee, M.D. for a Dermascan operation.

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