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# Sweat urea, uric acid and creatinine concentrations in uraemic patients

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**Abstract** Concentrations of creatinine, uric acid and urea were measured in the blood and urine of female patients at the final stage of renal disease and on a regular lifelong programme of haemodialysis. The samples were collected in wintertime and in summertime. The same analytes were also measured in sweat fluid at the time of collecting summer samples. The results showed insignificant physiological seasonal changes for creatinine and uric acid and that the concentration of these compounds in the sweat fluid was low. Urea concentration in the sweat fluid was found to be present at a much higher concentration than the serum level (reaching in some cases 50 times the serum level). The possibility of using thermal induction as an alternative to haemodialysis is suggested. The presence of urea in the sweat fluid at such a high level suggests a selective transport mechanism across the eccrine sweat gland to clear the blood of a high urea level.

**Key words** Sweat urea · Uraemic patients · Haemodialysis · Daily urea

## Introduction

Eccrine sweat fluid has been shown to contain several biochemical compounds of clinical interest [10]. Sweat analysis has been performed in various clinical conditions [4, 5]. Recently it has been shown that sweat fluid in diabetic patients contains a higher concentration of glucose and there is a reasonable indication of the presence of a correlation between sweat and serum glucose (Y. Y. Al-Tamer in preparation). Eccrine sweat fluid is a dilute electrolyte solution whose primary function is, as far as we know, to control body temperature [10]. Of the chemical compounds of sweat known to be excreted one is urea, which has been shown to increase severalfold after exercise [3]. In normal subjects, urea excretion has been shown to be age-related and can reach levels above 65 mmol/l in older people [1]. This particular point has initiated the present work. One of the major pathological disturbances in uraemic patients is the elevated serum urea concentration, which may be relieved by thermal sweating. In moderate and cold climate areas this may not seem to be practical. However, in areas where normal day temperature can reach 45°C the accompanying excessive excretion of sweat fluid, reaching 1500 ml/h [7], led us to consider the effect of extreme climatic changes on serum and sweat urea (and other nitrogenous compounds). In Mosul city where this study was conducted, the mean maximum temperature is (12.3°C) in winter and (41.2°C) in summer (Mosul Meteorological office personal communication). We have chosen uraemic patients as a model for this study.

## Materials and methods

### Subjects

Eleven female patients (two were anuretic), who were regular visitors to the Mosul dialysis centre, were chosen for the study. They all had end-stage renal disease and were on a regular lifelong programme of haemodialysis. They were all non-pregnant and taking aluminium hydroxide (200 mg) three times daily and vitamin $D_3$ (0.25 μg) twice daily. The majority of the patients paid a weekly visit to the unit (Table 1). Relevant information concerning these patients is presented in Table 1.

The dialysis instrument used was a Fresenius A10080 (Fresenius, Bad Hamburg, Germany). The dialysing solution was prepared locally according to the standard procedure and contained

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**Table 1** Clinical information concerning uraemic patients studied (all patients are female)

| Patient | Age (years) | Duration of Illness (years) | Duration of treatment | Number of dialysis/week[c] |
|---|---|---|---|---|
| 1 | 49 | 4 | 4 months | 1 |
| 2 | 35 | 6 | 2 years | 1 |
| 3 | 22 | 6 | 6 years | 1 |
| 4 | 50 | 3 | 12 months | 1 |
| 5 | 21 | 3 | 12 months | 1 |
| 6 | 19 | 2 | 2 months | 1 |
| 7 | 38 | 5 | 12 months | 1 |
| 8 | 50 | 6 | 1 month | 1 |
| 9[a] | 40 | 3 | 10 months | – |
| 10[b] | 25 | 8 | 7 years | 2 |
| 11[b] | 20 | 6 | 4 years | 2 |

[a] This patient/received dialysis twice a month
[b] These patients could not produce urine in sufficient quantities for analysis and were regarded as anuretic
[c] Dialysing time 5–7 h

the following components: NaCl, 17 mmol/l; $MgCl_2$, 10.5 mmol/l; $CH_3COONa$, 12.2 mmol/l; $CaCl_2$, 9 mmol/l; KCl, 14.3 mmol/l; glucose, 5 mmol/l. Usually 200 l of the solution was used for each patient per visit.

Sample collection

*Serum*

Venous blood samples (10 ml) were drawn in the morning just before the dialysis. The samples were allowed to clot in a water bath at 37°C then centrifuged. Each serum sample was divided into three portions, and then kept frozen at −18°C in capped glass tubes for not more than 3 weeks before use for analysis.

*Urine*

Patients were given plastic containers each containing a few drops of 0.1 NHCl for urine collection. They were instructed to start the collection the day before their turn in the dialysis unit by discarding the first morning sample and to continue collection until the first morning sample of the next day. They brought the containers with them when they came for dialysis. The volume of the samples was recorded and suitable portions of the urine (5–10 ml) were kept in separate capped glass tubes at −18°C for not more than 3 weeks before they were analysed.

*Sweat fluid*

On the days of dialysis during the summer, patients were asked to stay in a room maintained without cooling with an ambient temperature of 40–45°C (which represents a normal day temperature during the summer months in Iraq). The facial areas of the patients were cleaned with water and dried just before entering the room. Fifteen minutes after entering the room, drops of sweat started to accumulate on the chins of the subjects. These drops were collected using a plastic disposable syringe, and after a further 5 min 1–1.5 ml of sweat fluid had usually accumulated. These samples were then divided into three portions each, placed in clean capped glass tubes and kept frozen at −18°C for not more than 3 weeks before use for analysis.

Methods

Urea measurements were performed using the diacetyl monoxime method [11], creatinine was assayed using the Jaffe alkaline picrate method [2] and uric acid was measured using the phosphotungstic acid method [6]. Pooled human serum was used as a quality control sample. The coefficient of variation was less than 5% for the tested quantities. Chemicals and reagents were obtained from Fluka Chemie, Buchs, Switzerland and BDH, Poole, UK.

## Results

Although urea represents most of the waste nitrogenous compound excreted, it was our aim to investigate other waste nitrogenous products that could also be excreted via the sweat fluid. Therefore, creatinine and uric acid were also measured.

The results of these analyses are presented in Table 2 for uric acid, Table 3 for creatinine and Table 4 for urea. The tables include the concentration of these parameters in serum, urine and in sweat fluid (in summer). The total amount of these substances excreted in 24 h through the urine was also calculated.

**Table 2** Concentration (mmol/l) of uric acid in serum, urine and sweat fluid in uraemic patients studied in winter and in summer

| Patient | Winter | | | Summer | | | |
|---|---|---|---|---|---|---|---|
| | Serum | Urine | mmol/24 h[a] | Serum | Urine | mmol/24 h[a] | Sweat |
| 1 | 0.23 | 0.25 | 0.07 | 0.2 | 0.16 | 0.03 | 0.03 |
| 2 | 0.26 | 0.14 | 0.05 | 0.24 | 0.15 | 0.03 | 0.05 |
| 3 | 0.12 | 0.35 | 0.21 | 0.27 | 0.25 | 0.05 | 0.06 |
| 4 | 0.14 | 0.32 | 0.01 | 0.40 | 0.11 | 0.02 | 0.04 |
| 5 | 0.15 | 0.12 | 0.16 | 0.2 | 0.13 | 0.17 | 0.02 |
| 6 | 0.2 | 0.08 | 0.09 | 0.3 | 0.23 | 0.05 | 0.03 |
| 7 | 0.13 | 0.27 | 0.15 | 0.11 | 0.18 | 0.23 | 0.02 |
| 8 | 0.15 | 0.17 | 0.02 | 0.29 | 0.39 | 0.08 | 0.03 |
| 9 | 0.08 | 0.13 | 0.16 | 0.31 | 0.22 | 0.32 | 0.05 |
| 10[b] | 0.32 | – | – | 0.35 | – | – | 0.05 |
| 11[b] | 0.17 | – | – | 0.04 | – | – | – |

[a] Total urinary excretion
[b] Patients were anuretic

**Table 3** Concentration (mmol/l) of creatinine in serum, urine and sweat fluid in uraemic patients studied in winter and in summer

| Patient | Winter | | | Summer | | | |
|---|---|---|---|---|---|---|---|
| | Serum | Urine | mmol/24 h[a] | Serum | Urine | mmol/24 h[a] | Sweat |
| 1 | 0.42 | 0.23 | 0.06 | 0.26 | 0.06 | 0.01 | 0.06 |
| 2 | 0.31 | 0.10 | 0.04 | 0.30 | 0.26 | 0.04 | 0.05 |
| 3 | 0.47 | 0.40 | 0.24 | 0.38 | 0.05 | 0.01 | 0.06 |
| 4 | 0.37 | 0.19 | 0.01 | 0.32 | 0.43 | 0.01 | 0.06 |
| 5 | 0.33 | 0.20 | 0.27 | 0.31 | 0.17 | 0.22 | 0.14 |
| 6 | 0.43 | 0.36 | 0.42 | 0.2 | 0.31 | 0.27 | 0.03 |
| 7 | 0.31 | 0.41 | 0.23 | 0.27 | 0.72 | 1.15 | 0.17 |
| 8 | 0.44 | 2.1 | 0.21 | 0.35 | 2.55 | 0.5 | 0.07 |
| 9 | 0.33 | 0.24 | 0.29 | 0.18 | 0.14 | 0.20 | 0.09 |
| 10[b] | 0.56 | – | – | 0.32 | – | – | 0.34 |
| 11[b] | 0.50 | – | – | 0.31 | – | – | 0.09 |

[a] Total urinary excretion
[b] Patients were anuretic

**Table 4** Concentration (mmol/l) of urea in serum, urine and sweat fluid in uraemic patients studied in winter and in summer

| Patient | Winter | | | | Summer | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Serum | Urine | Urine volume (ml) | mmol/ 24 h[a] | Serum | Urine | Urine volume (ml) | mmol/ 24 h[a] | Sweat |
| 1 | 18.1 | 58.2 | 265 | 15.4 | 17 | 25.5 | 204 | 5.2 | 679.5 |
| 2 | 34 | 36.1 | 320 | 13.7 | 18.5 | 23.7 | 170 | 4.0 | 101.4 |
| 3 | 19.8 | 28 | 605 | 16.1 | 15.9 | 28.0 | 210 | 5.9 | 253.1 |
| 4 | 18.3 | 18.4 | 45 | 0.80 | 10.3 | 24.3 | 14 | 0.34 | 143.6 |
| 5 | 36.6 | 39.7 | 1350 | 53.6 | 18.5 | 20.7 | 1300 | 26.9 | 379.4 |
| 6 | 28.4 | 46.7 | 1170 | 54.6 | 11.4 | 15.3 | 900 | 13.6 | 118.9 |
| 7 | 30.8 | 54.5 | 870 | 47.4 | 20.5 | 21.8 | 1050 | 22.9 | 380 |
| 8 | 35.5 | 44 | 310 | 13.6 | 24.2 | 20.3 | 200 | 4.0 | 481 |
| 9 | 53.2 | 56.7 | 1220 | 69.2 | 10.1 | 15.7 | 1450 | 22.7 | 530 |
| 10[b] | 39.0 | – | – | – | 24 | – | – | – | 293.1 |
| 11[b] | 33.1 | – | – | – | 20.6 | – | – | – | 253.1 |

[a] Total urinary excretion
[b] Patients were anuretic

## Discussion

Sample collection of the sweat fluid was as quick as possible; nevertheless, inevitable evaporation during the collection cannot be ruled out. However, this may be minimal and does not affect the general conclusion.

The results for creatinine and uric acid concentrations (Tables 2, 3) were not conclusive in as far as seasonal variations were concerned. The amount of these analytes excreted by sweat fluid in summer was not high enough to consider the sweat as an important route for excreting these parameters. Therefore the conclusion here is that for these parameters the sweat fluid represents a simple leakage from the blood and perhaps this has little or no physiological importance. However, we could not find any reports on the sweat concentration of these analytes in normal or diseased subjects. Urea concentration (Table 4), on the other hand, was the most significant parameter. From the results in Table 4 the following observations can be made:

(a) Serum urea concentration in summer is generally lower and could be as low as one-fifth of its winter level (patient 9).
(b) Molar concentration of urea in the urine in summer may stay the same or may be reduced at various degrees.
(c) The total amount of urea excreted in the urine in 24 h in summer is generally much smaller than the amount excreted in winter (one quarter of the quantity excreted in winter as in patient 6).
(d) No relationship could be found between serum urea concentration, sweat urea concentration and urine urea concentration.
(e) The amount of sweat fluid required to excrete an equivalent amount of urea excreted in urine in 24 h ranges from 2.4 ml (patient 4) to 125 ml (patient 6). This amount could be excreted in 15 min or less for normal unacclimatized subjects and in a shorter time for acclimatized subjects in hot weather [7].

Sweat (thermally stimulated) urea concentration in uraemic patients obtained in this study was much higher than in normal subjects reported earlier. The highest normal level in females was found to be 56.6 mmol/l in older subjects [1] while the lowest level found in this study in uraemic patients was twice this figure and could be as much as 15 times higher. A more striking result is the difference in the urea concentration between serum and sweat fluid. We found that the urea sweat concentration could reach 50 times the serum concentration (patient 9) and only in one patient was it as low as 5.5 times (patient 2), while in the rest of the patients studied it was at least 10 times. These findings, in our opinion, are new and may raise the question of the importance of the eccrine sweat gland as a natural alternative route for the excretion of waste products, particularly when the kidneys are damaged and their functions are impaired. Since haemodialysis has, as its primary goal, the removal of uraemic toxins and excess fluid [9], we see no reason why this is not replaced by excessive thermal sweating. The validity of this suggestion will surely be examined and evaluated further, but the present results are highly indicative.

It has been previously reported that sweat urea at a higher level than that in serum is not representative of sweat gland function but rather of residual urea in the sweat duct being washed out [8]. We believe that this is not necessarily true. On the basis of this study we believe that urea transfer across the eccrine sweat gland is in fact a selective process designed to remove the excessively high level of urea present in the blood, whether this is carried out by a specific carrier or by active transport or even by a specific pump remains to be answered.

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