Taste Sensitivity Is Altered in Patients with Chronic Renal Failure Receiving Continuous Ambulatory Peritoneal Dialysis¹,²

Robyn A. Middleton and Margaret A. Allman-Farinelli³

Human Nutrition Unit GO8, University of Sydney, New South Wales 2006, Australia

ABSTRACT Decreased taste sensitivity may be one of the many factors influencing the poor nutritional status of many patients with chronic renal failure. Several studies examining taste in chronic uremic and hemodialysis (HD) patients indicate decreased sensitivity; continuous ambulatory peritoneal dialysis (CAPD) patients, however, warrant investigation. The aim of this study was to determine if the taste detection threshold for each of the four tastes (sweet, salty, sour and bitter) differs between CAPD patients and age and sex matched controls with normal renal function. The thresholds were determined using Cornsweet’s staircase technique for increasing and decreasing stimulus concentration, in which the subject’s response determines the next concentration to be tested. A forced-choice design using three samples was used to help minimize bias. The taste detection threshold for the CAPD patients was significantly higher than that of the controls for sodium chloride (salty) (P = 0.01) and quinine (bitter) (P = 0.01). This information may be useful when designing dietary supplements and devising meal plans to help patients consume nutritionally adequate diets. J. Nutr. 129: 122–125, 1999.

KEY WORDS: • continuous ambulatory peritoneal dialysis • hemodialysis • detection threshold • recognition threshold • taste sensitivity • humans

Patients with renal failure have decreased taste sensitivity (Atkin-Thor et al. 1978, Brouns Schiro and Eveleen Olin 1988, Burge et al. 1979, Ciechanover et al. 1980, Fornari and Avram 1978, Shepherd et al. 1986, Vreman et al. 1980). The four qualities of taste are sweet, salty, sour and bitter. Both patients with chronic uremia and those undergoing hemodialysis (HD) have been studied, and sweet and sour have commonly been shown to be affected. Taste improves immediately after a dialysis session although not to normal levels (Burge et al. 1979, Ciechanover et al. 1980, Fornari and Avram 1978, Shepherd et al. 1986 and 1987), implicating an accumulation of toxins between dialyses in the etiology; however, the responsible toxins have not been determined (Getchell 1991).

Continuous ambulatory peritoneal dialysis (CAPD) is increasingly the first line of renal replacement therapy, but few studies have examined taste in CAPD patients. Because the dialysis process differs from HD, it cannot be assumed that taste will be affected in the same way. CAPD involves a steady state of solute removal, whereas the intermittent nature of HD results in greater fluctuation in solute concentrations.

Inadequate dietary intake is one factor contributing to poor nutritional status (Allman et al. 1990). Taste influences food palatability and appetite; however, this link between taste sensitivity and food consumption is largely unstudied in renal patients. One study in HD patients demonstrated that improvement in taste acuity (by zinc supplementation) was accompanied by an increase in energy intake of 2.8 MJ/d (Atkin-Thor et al. 1978). It was necessary to obtain baseline data on taste acuity in CAPD patients before investigation into the presence of a relationship with food intake was undertaken (Fernstrom et al. 1996, Smith Hurley et al. 1987).

The most traditional way of assessing taste function is to use the threshold sensitivity. Taste sensitivity can be measured in two ways, taste detection and recognition threshold. The taste detection threshold is defined as the lowest concentration of a solution that can be distinguished from water. The recognition threshold is the lowest concentration of a solution at which the taste sensation such as sweet can be recognized.

The objective of this study was to test the hypothesis that renal patients receiving CAPD have a higher detection threshold for one or more of the four tastes than do matched controls.

MATERIALS AND METHODS

Subjects. A total of 36 subjects were studied. The selection criteria for all of the subjects included the following: nonsmokers, absence of a chronic disease that could affect taste (such as cancer or insulin-dependent diabetes) and having received CAPD for at least 2 mo.

The CAPD patients studied were under the care of the Central Sydney Area Health Service. Eighteen out of a possible 42 agreed to participate. The reasons for nonparticipation included feeling too unwell and lack of time or lack of transport to the testing site. The usual CAPD regimen was four bag exchanges per day with 15g/L or 25g/L dextrose or an overnight cycler that exchanges four bags over ~8 h. Serum urea and creatinine concentrations were obtained from the patients medical records; all had been measured within a 3-mo...
period of the taste-testing procedure. “Dry” weights, the clinical approximation of weight in fluid balance, were used for the calculation of body mass index of the CAPD patients.

Eighteen people with normal renal function were recruited as controls. They were matched with the CAPD patients for age and sex. Written informed consent was obtained from all of the subjects who participated. The study was approved by the Central Sydney Area Health Service and Sydney University Ethics Committees.

Taste testing procedure. The solutions used for the evaluation of taste detection threshold were sucrose (CSR, Sydney, Australia) for sweet, sodium chloride (Saxa, Sydney, Australia) for salty, citric acid (David Craig and Co., Sydney, Australia) for sour and quinine dihydrochloride (Ophthalmic Labs, Sydney, Australia) for bitter. All solutions were made with demineralized water as solvent. Table 1 lists the concentrations of each solution. All solutions were freshly made every 2 d and served to each subject at room temperature. The testing cups were made of plastic (Solo Cups, Chicago, IL).

Subjects were tested in the morning after an overnight fast of at least 10 h. This meant that all of the subjects were under similar conditions when testing was conducted so that residual food or differing hunger and satiety would not influence the tests.

Subjects were seated in a quiet room with minimal visual and olfactory distraction. The testing procedure used a multiple forced-choice sample presentation with an ascending series (American Society for Testing and Materials 1985a). Three cups were presented to each of the subjects in a prerandomized order. Two cups contained 10 mL of distilled water and the other cup contained 10 mL of the test solution. The subject tasted the solutions from left to right, taking all of the solution into the mouth, swishing it around and then expectorating it. The subjects were asked to choose which one of the three was different. An answer was required even if no difference was detected. Water rinses were used between each set of three samples to prevent carry-over from one sample set to another. The solution concentration at which testing began was two or three concentration steps below the estimated threshold found in the literature (Bales et al. 1986, Fornari and Avram 1978, Grzegorczyk et al. 1979, Vreman et al. 1980, Weiffenbach et al. 1982).

The detection threshold was determined according to a method based on the Cornsweet’s staircase method (Cornsweet 1962). A change in response from correct to incorrect or visa versa was designated a turn. Testing continued until six turns were recorded. The taste detection threshold for each subject was taken as the average of the last four concentrations at which a turn occurred. The taste detection threshold for each subject was assigned a rank number; for example, if the threshold found was between the first and the second concentration values, the rank assigned was a one. Multiple values for taste detection threshold by a tester at a given time were shown to be reproducible to within one rank for 100% of tests and to the same rank for at least 75% of the tests. This is in agreement with the findings of others (American Society for Testing of Materials 1985b).

Data analysis. Data were analyzed using Statview (version 4.02, Abacus Concepts, Berkeley, CA). A mean taste detection threshold and SD were calculated for each group and a comparison was made between the two. The Wilcoxon rank-sign test was used to assess whether the taste detection thresholds were different between the two subject groups (Altman 1991). A probability of \( P < 0.01 \) was taken as an acceptable level of significance because four tests were conducted. Simple linear regression was used to examine the relationship between the taste detection threshold and length of time receiving CAPD, serum urea and creatinine and age (Altman 1991). Body mass indices of the two groups were compared using the unpaired \( t \) test.

RESULTS

Table 2 summarizes the demographic and clinical characteristics of the two groups.

Body mass index did not differ between the two groups. The detection thresholds for sodium chloride (salty) and quinine (bitter) were higher in the CAPD patients compared with the controls (\( P < 0.01 \) (Fig. 1). There was no significant correlation between the detection thresholds and the patients length of time receiving CAPD nor with serum urea and creatinine. Age significantly correlated with the detection threshold for sucrose (sweet) \( [r = 0.39 \text{ (} n = 36) \text{, } P = 0.02] \). There was a strong correlation between age and the detection threshold for sucrose for all females \( r = 0.69 \text{, (} n = 14) \text{, } P = 0.007] \).

| TABLE 1 | TABLE 2 |

<table>
<thead>
<tr>
<th>Rank2</th>
<th>Sucrose</th>
<th>Sodium chloride</th>
<th>Citric acid</th>
<th>Quinine dihydrochloride</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mmol/L</td>
<td>µmol/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.31</td>
<td>0.0056</td>
<td>0.056</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.56</td>
<td>0.18</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.0</td>
<td>0.31</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1.8</td>
<td>0.56</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3.1</td>
<td>1.0</td>
<td>0.056</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>5.6</td>
<td>1.8</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>3.1</td>
<td>0.18</td>
<td>1.8</td>
</tr>
<tr>
<td>8</td>
<td>18</td>
<td>5.6</td>
<td>0.31</td>
<td>3.1</td>
</tr>
<tr>
<td>9</td>
<td>31</td>
<td>10</td>
<td>0.56</td>
<td>5.6</td>
</tr>
<tr>
<td>10</td>
<td>56</td>
<td>18</td>
<td>1.0</td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>100</td>
<td>31</td>
<td>1.8</td>
<td>18</td>
</tr>
<tr>
<td>12</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>31</td>
</tr>
</tbody>
</table>

1 Solutions were made with demineralized water.
2 Numbers were assigned to each concentration for analysis purposes.

FIGURE 1 Taste detection threshold of continuous ambulatory peritoneal dialysis patients and controls. Values are mean rank ± SD, \( n = 18 \).

* \( P = 0.01 \), ** \( P = 0.001 \).
DISCUSSION

Patients receiving CAPD demonstrated higher taste detection thresholds than controls for NaCl (salty) and quinine (bitter). The thresholds found are higher than those reported for normal subjects and renal patients (Bales et al. 1986, Fornari and Avram 1978, Grzegorczyk et al. 1979, Vreman et al. 1980, Weiffenbach et al. 1982). This study used three samples in each trial, whereas most studies use only two samples, increasing the probability of guessing the correct answer. Therefore, higher thresholds are obtained when using three samples (Grzegorczyk et al. 1979).

Two studies have previously examined taste acuity in CAPD patients. Smith Hurley et al. (1987) used a qualitative assessment of perceived intensity of a range of different salt concentrations. The 10 CAPD patients did not differ from the controls. Fernstrom et al. (1996) studied the four tastes by assessing recognition thresholds in 17 CAPD patients. Compared with controls, the patients’ bitter taste was impaired, but no difference was detected for salty taste. The differences between that study and ours may reflect subject variability or the use of different methods. In a pilot study of 12 patients by our group (I. Van der Eijk, Student University of Maastricht, personal communication), the recognition threshold for salty was higher in the patients but the detection threshold was not impaired. However, this study used only two samples in each trial.

Smith Hurley et al. (1987) reported that CAPD patients had a higher intake of salt than HD and transplant patients and a preference for salty items compared with the controls. Dobell et al. (1993) also found that CAPD patients had a preference for salty foods. It is plausible that if people are less sensitive to the salty taste, they will require a greater concentration of the substance compared with controls and hence might prefer saltier foods. However, the link between sensitivity and salt intake has not been substantiated (Mattes 1984).

The taste intensity of sodium may depend on prior adaptation. The taste receptors are bathed in saliva and adapt to the sodium level of this fluid. (Delwiche and O’Mahony 1996, Mattes 1997). To elicit a salty sensation, this level must be exceeded by a given amount (Mattes 1984). Therefore, an individual with an increased salivary sodium concentration would have a higher threshold for salty. However, in the current study, serum sodium and salivary sodium were not measured; thus correlations between these and the salty detection threshold could not be identified. It is possible that sodium levels in the dialysate could affect taste threshold. Fernstrom et al. (1996) also found CAPD patients to have a decreased sensitivity to bitter taste. However, the explanation for the dysfunction of taste acuity for bitter in CAPD patients is unknown. Among the explanations for renal patients having impaired taste are metabolic disturbances, deficiencies of multiple micronutrients due to decreased food intake (zinc deficiency has been frequently implicated, Atkin-Thor et al. 1978, Bunge et al. 1984, Shepherd et al. 1986, Vreman et al. 1980), kidney dysfunction and alterations of peripheral nerve function (Getchell 1991). Drugs may also either decrease or increase the sensitivity to a certain taste; thus medication remains a confounding variable in most studies of taste in renal patients (Van Der Eijk and Allman-Farinelli 1997). However, neither the reasons for impaired taste nor the effects of medication have been elucidated or specifically related to CAPD patients.

The partial improvement of taste observed after HD indicates that an accumulation of toxins may be responsible in part for impaired taste in renal patients. CAPD is a continuous, rather than intermittent, dialysis process like HD. This results in CAPD patients having a steady state of solute removal, whereas HD can bring about wide fluctuations in solute levels. It is likely therefore that taste acuity would be affected differently. This is congruent with the findings in this study in which CAPD patients had impaired taste for salty and bitter, whereas most of the studies investigating chronic uremics or HD patients reveal impaired taste acuity for sweet and sour.

Many studies have demonstrated an inverse relationship between age and taste (Bales et al. 1986, Grzegorczyk et al. 1979, Moore et al. 1982, Spitzer 1988, Weiffenbach et al. 1982). They have found that older people have a higher taste sensitivity threshold. This effect was demonstrated only for the detection threshold for sucrose (sweet) in this study. The effect of age does not bias these results because the patients and controls were matched for age. Previous studies of renal patients (Burge et al. 1979, Fernstrom et al. 1996) indicated that as serum urea rises, the taste sensitivity diminishes. However, in this study, no relationship with either urea or creatinine was found.

In conclusion, we found that CAPD patients had impaired salty and bitter taste. This may be one of a host of factors influencing food intake. Further research to evaluate the effect of taste on food intake and to develop meal plans and nutritional supplements that incorporate taste sensitivity and preferences is indicated.

ACKNOWLEDGMENTS

We are grateful to Ingrid Van Der Eijk who did the preliminary work that enabled the current study and to P. Lyons Wall for sharing her expertise on taste testing. We also thank Adrian Gillan and the staff at Dame Edith Walker, Dialysis Training Center, Central Sydney Area Health Service for their cooperation and assistance and all of the subjects who participated in the study.

LITERATURE CITED


TASTE CHANGES IN RENAL PATIENTS


