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Taste acuity in patients undergoing long-term hemodialysis

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Taste acuity in patients undergoing long-term hemodialysis. Recognition taste thresholds for the four primary tastes, sour, sweet, salty, and bitter, were determined in 18 patients (age range, 17 to 65 years) with end-stage kidney disease and were compared to 10 age and sex matched controls. In experimental subjects, mean taste thresholds before and after dialysis for tartaric acid were 0.004 N and 0.002 N, respectively, compared to 0.0002 N for controls. For sucrose, before and after dialysis, mean taste thresholds were 0.039 M and 0.023 M, respectively, and 0.014 M for controls. When we used the same taste modalities, that is, sweet or sour, all possible comparisons were significant except the one for sweet between patients after dialysis and controls. Mean recognition taste thresholds for salty and bitter were not significantly impaired in dialysis patients when compared to controls. Mean serum zinc concentrations were 77 μg/dl, both before and after dialysis. Since these are low-normal values, zinc could be a contributing factor in loss of taste among these patients, but it can't explain the improvement seen in taste acuity associated with dialysis for 6 to 8 hours. Since taste acuity improved with dialysis, it is conceivable that recognition taste thresholds could be adapted so that they could complement or substitute for the current serum urea kinetics calculations used in many programs to assess the adequacy of dialysis.

Acuité du goût chez les malades soumis à l'hémodialyse chronique. Les seuils de reconnaissance pour les quatre goûts primaires: acide, sucré, salé et amer, ont été déterminés chez 18 malades âgés de 17 à 65 ans, atteints d'insuffisance rénale terminale et ils ont été comparés à 10 contrôles appariés pour le sexe et l'âge. Parmi les sujets expérimentaux les seuils moyens pré- et post-dialyse pour l'acide tartrique ont été de 0,004 N et 0,002 N, respectivement, et de 0,002 N chez les contrôles. Pour le sucrose les seuils moyens pré- et post-dialyse ont été de 0,039 M et 0,023 M, respectivement, et de 0,014 M chez les contrôles. L'utilisation des mêmes modalités de goût, c'est-à-dire sucré ou acide, a permis de montrer que toutes les comparaisons possibles ont été significatives à l'exception de celle pour le sucré chez les malades après la dialyse et les contrôles. Les seuils moyens de reconnaissance pour le salé et l'amer ne sont pas significativement modifiés chez les malades en dialyse par comparaison avec les contrôles. Les concentrations moyennes de zinc étaient de 77 μg/dl, aussi bien avant qu'après la dialyse. Du fait que ces valeurs sont basses, le déficit en zinc pourrait expliquer la perte du goût chez les malades, mais elle ne peut expliquer l'amélioration de l'acuité du goût observée après une dialyse de 6 à 8 heures. Du fait que l'acuité du goût est améliorée par la dialyse il est concevable que les seuils de reconnaissance soient utilisés comme complément ou substitut des calculs de cinétique de l'urée sanguine employés dans de nombreux programmes pour évaluer l'adéquation de la dialyse.

Patients afflicted with end-stage kidney disease and who undergo chronic hemodialysis need to control their intake of protein, potassium, sodium, and phosphorus. Although the modified diets used as therapy for hemodialytic patients contain sufficient protein, it is extremely difficult for patients to obtain sufficient calories to assure use of protein for repletion of endogenous stores. In addition, energy intake in these patients is usually low, presumably because appetite is affected adversely. Both, an inability to adequately taste the food and the extreme dietary modifications reduce palatability. Evidence for disturbance in taste acuity came from observation of patients at the Michigan Nephrology Center. Chronic aversion to cakes and cookies was associated with persistent complaints about the extreme sweetness of these products. Likewise, most products designed to be protein- and electrolyte-free, yet high in carbohydrates and calories, have minimal acceptance because of excessive sweetness, even though tart flavors such as lemon and sour cherry have been incorporated into the product to offset the sweet taste.

Although there has been little or no work done on taste acuity with patients maintained on hemodialysis, other diseases have been known to affect taste. Hollingsworth and Paffenberger [1] reported that elevated blood glucose decreases sensitivity to sweetness. Enhanced sensitivity to taste has been reported in patients suffering from adrenal insufficiency [2] and in cystic fibrotic patients [3]. The latter is controversial, however, since Wotman, et al [4] and Desor and Maller [5] reported no dif-

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Table 1. Concentrations of solutions used for recognition taste testing for subjects on hemodialysis and controls

Hemodialysis			
Sucrose[a] *M*	Tartaric acid[a] *N*	Sodium chloride *M*	Quinine sulfate *M*
0	0	0	1
0.01	0.0001	0.005	2
0.02	0.0002	0.010	4
0.03	0.0004	0.020	8
0.04	0.0008	0.030	10
0.05	0.001	0.040	15
0.06	0.002	0.050	20
0.07	0.003	0.060	25
0.08	0.004	0.070	30
0.10	0.005	0.080	35
	0.006	0.090	40
	0.007	0.100	
	0.008		
	0.009		
	0.010		

[a] Additional dilutions between concentrations were tested for the second trials of these two taste modalities, that is, if subject recognized 0.06 M sucrose, the second trial would be 0.051, 0.052, 0.053, 0.054, etc.

ferences. In contrast, Cohen, Schechter, and Henkin [6] in 1973 reported hypogeusia among thermal burn patients. Depressed taste thresholds also occur in lung cancer [7]. The current investigation was undertaken to explore the effect of uremia on taste acuity.

Methods

Subjects. Eighteen ambulatory end-stage renal disease (ESRD) patients, who were routinely hemodialyzed for 6 hours three times per week at the Michigan Nephrology Center, were selected as experimental subjects. There were 9 males and 9 females between the ages of 17 and 65 years (mean age, 46.5 years). All 10 control subjects, 3 males and 7 females between the ages of 21 and 65 years (mean age, 45.8 years), were hospital personnel or patients' spouses.

Measurements of recognition thresholds for primary tastes. The solutions used for evaluation of each recognition threshold were USP purity quinine sulfate (bitter), tartaric acid (sour), sodium chloride (salty), and sucrose (sweet). All solutions were made fresh daily with sterile distilled water used as solvent. Table 1 lists the concentration of the solutions for each taste modality.

All subjects were asked to fast and not smoke for at least 2 hours prior to tasting. Recognition thresholds for representative solutions of the four primary tastes were determined in each subject. This was done between 0 and 30 min before dialysis and repeated between 0 and 30 min after dialysis. For tasting, each subject swished 10 cc of solution around in the mouth and then expectorated. The subject described the taste of each solution in the series as being either sweet, sour, salty, bitter, or having no taste and indicated the intensity of taste on a scale of one to ten (from slight to extreme). Each subject then waited 1 min before continuing to the next sample. After the subject correctly identified two consecutive samples, the sample with the lower concentration of solute was defined as the recognition threshold [8]. All subjects were tested for the same taste modality on at least two occasions. The patient did not necessarily receive the same taste modality both before and after dialysis on the same day.

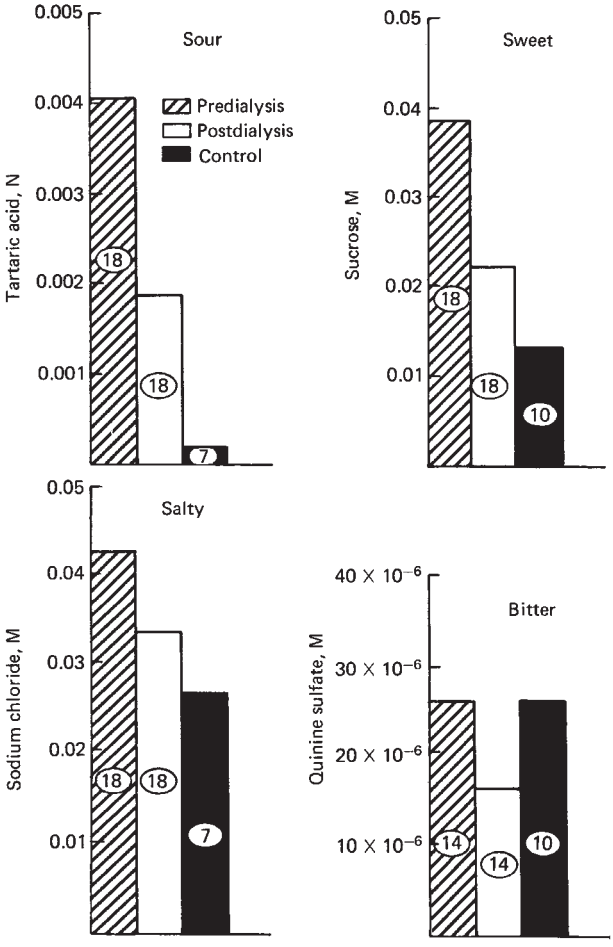

Fig. 1. *Mean taste recognition thresholds for sour, sweet, salty, and bitter for end-stage renal disease patients before and after hemodialysis and control subjects. Number in circle* on graphs indicates the number of subjects tested. For further clarification on subjects, see text.

Blood analyses. A 10-ml sample of blood was taken from the venous shunt of each experimental subject and by venipuncture from each control and was placed into heparinized tubes. Hematocrits were done, and the remainder of the blood was prepared for use as serum samples. The latter were frozen and subsequently analyzed for creatinine by the Folin and Wu technique [9] and serum urea nitrogen (SUN) by the technique of Marsch, Fingerhut, and Miller [10]. Serum zinc concentration was determined with an atomic absorption method [11] on 15 ESRD patients both before and after dialysis. Student's *t* test [12] was used to determine if significant differences existed between subjects before and after dialysis, as well as between experimental and control groups.

Results

Mean recognition thresholds. Mean recognition taste thresholds of tartaric acid (sour) for ESRD subjects before dialysis were significantly higher ($P < 0.001$) than those of control subjects (0.004 N vs. 0.0002 N) as shown in Fig. 1 and Table 2. Following hemodialysis, mean recognition taste thresholds improved ($P < 0.01$) twofold to a value of 0.002 N, but this was still significantly higher than that of controls ($P < 0.01$). Mean recognition taste thresholds for sucrose (sweet) of ESRD subjects before dialysis were also significantly higher ($P < 0.01$) than those of the controls (0.039 M vs. 0.014 M). Hemodialyses brought about significant improvement ($P < 0.05$) in the mean recognition taste thresholds for sweet, but at no time did it reach the levels of the control subjects even though differences between postdialytic patients and controls were never significant ($P > 0.05$).

Although the mean recognition taste thresholds of 0.043 M sodium chloride before dialysis and 0.034 M sodium chloride after dialysis were not significantly higher than the control value of 0.026 M sodium chloride, the mean value for pre- and postdialysis subjects was calculated using a recognition taste threshold of 0.100 M for four subjects who were unable to detect sodium (salty) below this range. Although ideally these subjects should have been further tested to identify their true recognition taste threshold, that was not possible since for various reasons they were no longer available to the unit. If, indeed, their true recognition taste threshold could have been determined, this group would surely have had a slightly higher mean recognition taste threshold, which may have approached significance. As serum urea nitrogens increased in value, there was a tendency for patients to be less able to detect saltiness.

Serum zinc concentrations for 15 experimental subjects ranged from 50 to 114 μg/dl before dialysis and 39 to 111 μg/dl after dialysis (Table 3). The remaining three subjects were not available for zinc analyses. Zinc serum values were in the low range for normal (75 to 160 μg/dl) for the method [11] used.

Table 2. Individual blood and serum values and recognition taste thresholds

	Serum urea nitrogen *mg/dl*		Serum creatinine *mg/dl*		Hematocrit % *whole blood*		Recognition taste threshold					
							Sour, N[b]		*Sweet, M*		*Salty, M*	
Subject	Pre[a]	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	112.0	36.0	13.4	5.7	23.5	27.0	0.0035	0.0002	0.07	0.07	0.026	0.020
2	106.0	42.0	10.2	5.2	24.0	26.5	0.0034	0.0011	0.07	0.07	0.03	0.018
3	104.0	46.0	17.0	8.9	23.0	25.0	0.0007	0.0009	0.041	0.003	0.014	0.006
4	104.0	34.5	12.8	5.5	15.0	15.0	0.0075	0.0049	0.002	0.002	0.022	0.007
5	102.0	44.5	11.6	6.6	25.0	27.0	0.010	0.009	0.07	0.06	>0.10	0.10
6	98.0	48.0	12.8	9.6	28.5	27.5	0.0033	0.0004	0.026	0.026	0.010	0.004
7	96.0	47.0	16.8	9.4	24.5	25.0	0.0033	0.0003	0.026	0.002	0.022	0.020
8	96.0	47.0	11.8	6.6	32.0	34.0	0.0056	0.0032	0.035	0.040	>0.1	0.054
9	84.0	29.5	11.8	4.6	17.5	20.0	0.005	0.001	0.016	0.011	0.028	0.028
10	82.0	38.0	13.8	6.6	23.5	24.0	0.0002	0.0003	0.060	0.016	0.028	0.020
11	74.0	29.0	14.0	6.7	27.0	27.0	0.0011	0.0015	0.070	0.009	>0.10	0.092
12	68.0	—	12.6	—	37.0	37.0	0.008	0.001	0.026	0.016	0.007	0.009
13	51.0	20.0	9.0	4.0	32.0	34.0	0.0042	0.0003	0.026	0.003	0.049	0.020
14	48.0	—	7.9	—	34.0	34.0	0.0033	0.0007	0.036	0.016	0.030	0.015

[a] Prehemodialysis or posthemodialysis
[b] Normal (*N*) or molar (*M*) solutions

Table 3. Zinc in serum of end-stage renal disease (ESRD) subjects

Status of subjects	N	Serum zinc, μg/dl		
		Mean	SD	Range
Predialysis	15	77	18	50–114
Postdialysis	15	77	18	39–111

Discussion

In accordance with subjective observations, end-stage renal disease patients (ESRD) undergoing hemodialysis had impaired ability to recognize primary tastes. Improvement of taste recognition thresholds occurred following hemodialysis.

Zinc has been implicated in many conditions associated with hypogeusia and may be a factor involved in the abnormalities seen in taste responses of ESRD patients [6]. Henkin et al [13] have shown that zinc acts as a cofactor in a gustatory protein called gustin. This protein has been proposed as the carrier of the chemical responsible for a particular taste to the taste receptor. The information concerning zinc metabolism among hemodialyzed patients is controversial. Mahler, Walsh, and Haynie [14] and Mansouri, Halsted, and Gombos [15] in 1970 reported decreased concentrations of serum zinc among end-stage renal disease patients, whereas Bloomfield, McPherson, and George [16] in 1969 and Rose, Path, and Willden [17] in 1972 reported normal or slightly elevated concentrations of serum zinc in their patients. Serum zinc values for patients in this study did not change after dialysis and were low-normal both before and after dialysis. Although several patients in this study had low-normal serum zinc concentrations, that there was improvement in taste acuity after dialysis would tend to disqualify zinc deficiency as an explanation for the observed hypogeusia, since serum zincs did not improve. Other measurements for zinc deficiency, however, should be investigated before completely discarding this hypothesis. It could be a partial explanation for the underlying abnormalities seen in the predialysis patients and the continued alterations seen in postdialysis sour results.

The taste threshold test is a relatively inexpensive and simple test which may be useful in assessing the adequacy of hemodialysis programs. Sour and sweet taste threshold measurements appear to be the most sensitive in delineating potential gustatory differences in these patients. These taste modalities are significantly impaired before dialysis and improve significantly with a single hemodialysis treatment.

End-stage renal disease patients who are maintained on routine hemodialysis have an increased need for calories. Many of these calories must come from low-electrolyte, low-protein sources. Many patients find it difficult to ingest sufficient amounts of these products, and consequently they lose body weight. One factor which affects palatability of food is the ability to taste the food. Identification of mechanisms for taste alterations should lead to correction, or at least a better understanding by professional personnel of the problems imposed upon these patients in acceptance of special diets. In addition, it could help the food industry to prepare palatable and acceptable foods for renal failure patients.

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