Serum Trace Elements in Elderly Frail Patients with Oropharyngeal Dysphagia

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Summary
Microelements have an important role in many vital enzymatic functions. Their optimal intake and serum concentration are not properly defined. For nursing home residents, this issue is further complicated by the high prevalence of oropharyngeal dysphagia. The purpose of this study was to measure microelement concentrations in 3 groups of elderly subjects that differ in their feeding methods and functional state. Forty-six frail elderly patients, in stable clinical condition, 15 on naso-gastric tube (NGT) feeding, 15 orally fed (OF), from skilled nursing departments were recruited to this study. As controls, we studied a group of 16 elderly independent ambulatory patients. A battery of 16 microelements was examined using the Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The OF frail elderly patients had significantly lower levels of chromium as compared to the NGT fed and the control group. Both frail elderly groups had lower levels of zinc and copper as compared to the controls. In contrast, in the nursing groups, we found higher levels of aluminum, boron, barium, bromine and nickel. Elderly, in particular frail and disabled subjects, are vulnerable to insufficiency or overload of microelements. There is a need to evaluate the actual requirements for each microelement for this population.

Key Words trace elements, frail elderly, oropharyngeal dysphagia

Eating ability of frail nursing home patients varies from normal oral intake through several degrees of dysphagia to tube enteral feeding (TEF). Dysphagia is highly prevalent in this population, reaching up to 60% (1, 2). Feeding is further complicated by the medical condition of these patients (poor cooperation, refusal) and by institutional factors (understaffing and insufficiently motivated personnel) (3–6).

With time, in many patients, dysphagia worsens. cooperation diminishes and food ingestion is increasingly difficult, insufficient and even dangerous, bringing TEF into consideration (7, 8). This feeding method is the fastest growing area of artificial feeding and in Israel it is often practiced by using naso-gastric tubes (NGT) (9).

Frail patients with dysphagia should be under constant supervision in order to ensure proper nutrition and initiate TEF before malnutrition develops. The nutritional evaluation of these patients is complicated by comorbidity, polypharmacy and by individual patterns of feeding.

An efficient way to categorize such patients by combining swallowing difficulties with the nutritional outcome is the Functional Outcome Swallowing Scale (FOSS) (10). The existence of an increasing number of TEF patients fed on balanced formulas under controlled intake makes it possible to compare their nutritional status with that of their counterparts with dysphagia. In previous studies, we found that compared with patients on TEF, the orally fed elderly, showed [previously undetected] nutritional deficits expressed by low levels of vitamin B12 and folic acid (11), and also a low CD4 lymphocyte count, which also suggests malnutrition (12). These deficits reflect parameters of undernutrition that should be detected on time and corrected.

The proper starting point for the initiating of TEF has hitherto been based on anthropomorphic indexes: body mass index (BMI) and albumin levels that were both described as insufficient (13, 14). It is therefore important, to look for additional parameters to get a more accurate nutritional status for the frail patients with oropharyngeal dysphagia.

Recently, the importance of micronutrients was emphasized with some of them considered either essential or beneficial for humans and the long term care system was instructed to ensure a proper daily intake (15, 16).

However, there is not enough information regarding serum trace element concentration and its relation to the feeding status of the frail elderly (17, 18).

The purpose of this study was to compare the serum concentrations of trace elements in three representative groups of the frail elderly: one with oropharyngeal dys-
phagia at an early stage (FOSS 2), the second on TEF (nasogastric tube feeding) and the third as a control group consisting of completely independent elderly.

**PATIENTS AND METHODS**

Long term care (LTC) patients with various comorbidities and clinically stable during the study period, were recruited to this study. It was approved by the Hospital Ethics Committee. Subjects with major medical problems such as decubitus ulcers of grade 2 and more, advanced cancer, severe heart failure, chronic liver diseases, chronic lung disease or renal insufficiency with serum creatinine >1.5 mg/dL were excluded.

Patients on diuretics were accepted with a maximal dose of 40 mg furosemid or 25 mg disothiazide. Also excluded were patients that received any vitamins or other supplements that were studied.

Two main study groups were examined: 15 patients on naso-gastric tube feeding (NGT) (FOSS 5), for at least 3 mo and 15 orally fed (OF), in the FOSS 2, both bedridden LTC patients. The NGT fed group received around 1,500 mL of either Easyfiber formula (Teva Medical, Israel) or Osmolite (Abbott Ohio, USA), and about 600 mL of additional water per day. The nutrition contents of the Easyfiber and Osmolyte are protein 4.4 and 3.7%, carbohydrates 15 and 14.4%, fat 3.5 and 3.7%, respectively. The orally fed received daily adequate nutrition and hydration according to the RDA requirements. All patients were supervised by the departments’ dietitian. The control group consisted of 16 independent ambulatory elderly patients examined at the outpatient clinic and screened to eliminate feeding problems.

The content of micronutrients in the formulas of those on NGT feeding, as well as a “rude” estimation for the other 2 study groups [based on the American RDA] are presented in Table 1.

Venous blood was obtained for the evaluation of the trace elements, before the morning meal. Serum samples were kept frozen (−25°C) until the analysis. These were performed by the laboratories of the Israel Geological Survey, Jerusalem.

After unfreezing all the samples were diluted ×10 with double distilled water (18 MΩ/cm), and submitted to analyses. The chemical composition of the serum was detected using two methods: Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The latter method provides better (lower) limits of detection. Concentrations of magnesium, iron, zinc, barium, aluminum, copper, and strontium were defined using ICP-AES (Optima 3300, Perkin Elmer). All trace element contents, including zinc, barium, aluminum, copper, and strontium, that were cross-checked, were defined using ICP-MS (Elan DRC II, Perkin Elmer Sciei) equipped with a flow injection sample introduction system. Good accordence was found between results obtained from the two instruments. Corrections of chlorine interferences (on vanadium, chromium and arsenic) were made using clean medical saline and of bromine (on selenium)—solution containing 5 mg/L bromine. Accuracy was checked by analyzing international standards of USGS and SRM NBS 1643a. Precision for minor and trace elements was less than 3–10% depending on the concentration. The levels of trace elements reported in the literature were collected and presented as ranges. Only values obtained by recently used methods were considered.

Statistical processing of data was performed by the SPSS software. Student’s t test, ANOVA, Pearson’s coefficient, chi square and Fisher’s exact test were used for evaluations. p<0.05 by 2 tail was considered significant.

**RESULTS**

Table 1. Daily nutritional supply of trace elements in elderly frail patients.

| Element        | Orally fed | NGT fed (formula)* |
|----------------|------------|--------------------|
| Magnesium, mg  | 320–420*   | 315–450            |
| Iron, mg       | 8*         | 14–20              |
| Copper, μg     | le 1,000*  | 1,580–2,250        |
| Zinc, mg       | 8–11*      | 11–20              |
| Selenium, μg   | 55*        | 57–81              |
| Boron, mg      | 20         |                    |
| Chromium, μg   | 20–30*     | 80–110             |
| Manganese, mg  | 1.8–2.3*   | 4–5.6              |
| Nickel, μg     | 1          |                    |
| Molybdenum, μg | 45*        | 120–160            |
| Cobalt         | —          |                    |
| Bromine        | —          |                    |
| Lithium, μg    | 220–600    |                    |
| Strontium      | —          |                    |
| Aluminum, mg   | 2–10       |                    |
| Barium         | —          |                    |

*Based on American RDA for females and males, respectively.
**Formula Osmolite or Easyfiber, 1,500 mL/d.
Missing numbers mean data not reported by the producer.

In Table 2 are shown the demographic data of the elderly patients of the 3 study groups; two groups of skilled nursing patients, 15 patients on NGT feeding and 15 orally fed (OF), both bedridden LTC patients, and a control group consisting of 16 independent ambulatory elderly patients visiting the outpatient clinic. The control group was naturally different from the nursing patients (both NGT and OF) because of the low incidence of stroke and dementia.

In Table 3 are shown laboratory data, representing the levels of trace elements in the serum of long-term care frail elderly, compared to ambulatory elderly (controls).

In the skilled nursing patients (both NGT and OF), we found significantly lower levels of several essential trace elements as compared to the control group: chromium, zinc and copper. The levels of chromium were significantly lower in the orally fed frail elderly, as a matter of
levels of the other studied trace elements: cobalt, selenium, iron, molybdenum, magnesium manganese and strontium.

**DISCUSSION**

Low levels of three of the most important trace elements, zinc, chromium and copper, were found in the 2 groups of frail elderly patients.

This was our early presumption because of the feeding difficulties in the orally fed group and the frailty of the NGT group. It was rather expected in view of our previous experience with this category of patients (11–13) and it supports our view that the orally fed (FOSS-2) are in a condition with high potential of under-nutrition. The most significant deficiency was observed in the values of zinc, not only as compared to our control group, but also to the literature values. Zinc is essential in many vital functions including adequate function of the immunological system, which is particularly important for elderly frail patients (19).

With respect to chromium, the extremely low levels in the orally fed frail elderly are noteworthy. The relevance of low serum levels of chromium found in our orally fed frail elderly may be related to glucose metabolism. Chromium is known for its beneficial influence on the glucose level in diabetic patients (20, 21). The presumption is that chromium supplementation works whenever its blood level is low (21). However, chromium levels in diabetic patients are not examined before chromium supplementation. Glucose metabolism is disturbed in many elderly patients because of various degrees of insulin resistance. In a previous study, we have shown that addition of chromium improved their diabetic control (22).

The level of these three elements in the control group

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Table 2. Demographics of elderly patients in study: ambulatory (controls) vs nursing patients fed orally (OF) or by nasogastric tube (NGT).

| No. | Control | OF | NGT | p1 |
|-----|---------|----|-----|----|
| Age | 77±7 | 82±5 | 78±6 | N.S. |
| Female/male (%) | 3/13 | 3/12 | 4/11 | N.S. |
| Isch. heart dis. (%) | 6 (37) | 8 (53) | 11 (73) | N.S. |
| Cong. heart dis. (%) | 4 (25) | 4 (27) | 5 (33) | N.S. |
| Hypertension (%) | 12 (75) | 8 (53) | 7 (47) | N.S. |
| Cerebro vasc. dis. (%) | 4 (25) | 6 (40) | 7 (47) | 0.001 |
| Diabetes (%) | 2 (12) | 2 (13) | 3 (20) | N.S. |
| Dementia (%) | 1 (6) | 10 (67) | 8 (53) | 0.002 |
| Cerebro vasc. dis. (%) | 7 (44) | 0 | 0 | N.S. |
| Chr. lung dis. | 1 (6) | 2 (13) | 3 (20) | N.S. |
| Peptic disease | 8 (50) | 10 (67) | 6 (40) | N.S. |
| Renal failure | 2 (12) | 1 (7) | 1 (7) | N.S. |
| Relevant drugs (%) | | | |
| Diuretics | 4 (25) | 6 (40) | 4 (27) | N.S. |
| Antihypertensive | 11 (69) | 5 (33) | 5 (33) | N.S. |
| Antacids | 6 (37) | 2 (13) | 5 (33) | N.S. |
| Laxatives | 8 (50) | 10 (67) | 14 (93) | N.S. |
| Diabetic drugs | 1 (6) | 1 (7) | 4 (27) | N.S. |
| Anti-lipid | 6 (37) | 1 (7) | 0 | 0.005 |
| Bisphosphonates | 5 (31) | 0 | 0 | 0.001 |
| Tranquilizers | 0 | 6 (40) | 7 (47) | 0.001 |

NGT, nasogastric feeding; OF, orally fed.

p1: Comparing NGT fed with OF nursing elderly.

Data is in patient numbers and (%).

Table 3. Serum trace elements of ambulatory (controls) vs nursing patients fed orally (OF) or by nasogastric tube (NGT).

| Element | Controls | Frail-oral feeding | Frail-NGT feeding |
|---------|----------|-------------------|-----------------|
| No. | 16 | 15 | 15 |
| Magnesium | 16,000±2,000 | 16,000±3,000 | 16,000±1,000 |
| Iron | 1,000±500 | 1,000±800 | 1,200±700 |
| Copper | 1,300±300b | 1,100±200a | 1,000±200a |
| Zinc | 640±124b | 440±111a | 430±117a |
| Selenium | 121±28 | 112±29 | 121±37 |
| Boron | 39±22a | 72±26b | 71±38b |
| Chromium | 33.0±8.1c | 0.1±11.0a | 14.3±16.7b |
| Manganese | 5.2±0.75 | 5.1±0.2 | 5.0±0.1 |
| Nickel | 4.4±1.3a | 7.1±2.4b | 5.7±1.9b |
| Molybdenum | 2.3±0.7 | 2.2±1.1 | 3.3±2.0 |
| Cobalt | 1.1±1.2 | 1.4±0.5 | 1.8±0.7 |
| Bromine | 6,700±2,000a | 10,400±5,000b | 23,700±10,600f |
| Lithium | 153±52a | 28±18a | 32±21a |
| Strontium | 59±21 | 48±20 | 45±21 |
| Aluminum | 35±24a | 93±66b | 78±61b |
| Barium | 5.0±0.2b | 14.0±8.2c | 9.3±5.9b |

All values in μg/L. Comparisons by ANOVA between control ambulatory elderly and frail elderly fed by oral or nasogastric tube (NGT).

Values, on the same, line with different superscript letter, differ statistically. All values were of p<0.001, except for that for nickel, which was p<0.05.
is compatible with the normal limits published in the literature (23) pointing to a satisfactory intake of this group. As mentioned earlier, it is not surprising that the group with mild dysphagia (FOSS-2) have low concentrations of these three elements. What is rather surprising is their low level in the serum of the TEF group. These patients are fed by balanced formulas and under controlled intake were expected to have satisfactory levels. The possible failure of TEF formulas to provide acceptable levels of zinc and copper should be further explored.

Several trace elements were higher in the nursing group as compared to the control group: boron, aluminum, barium, nickel and bromine. It may suggest an accumulation effect due to a lower renal or hepatic clearance in the frail elderly.

Another group of elements were found at similar levels in all three groups: manganese, strontium, cobalt and molybdenum were in the range reported as within normal limits. These elements are not directly related to hitherto known clinical conditions.

Some values obtained in this study were not in concert with previous published data. The levels of aluminum, chromium, lithium, barium, boron and bromine were higher while those of zinc and manganese were lower in our study as compared with other studies (23). These differences may be explained by the method of analysis. Last year’s new instrumentation, Atomic Emission Spectrometry, enables us to measure microelement concentrations in human fluids more accurately than previously used methods (24, 25). In addition, geographical location, dietary habits, age and other possible factors may cause these differences.

Although microelements are vital to enzymatic activity, transporters activities, free radical scavenging, and other protein activities, not enough knowledge has been accumulated for the real requirements of many microelements, particularly in frail elderly patients. For some, the optimal concentration for the best physiological body functions lay at a narrow range.

There is a need to evaluate the actual requirements for each microelement for the elderly population. Since long-term care frail patients, completely feeding dependent, are expected to increase in numbers and in terms of life expectancy we should extend the nutritional follow-up to include trace elements. Further studies including larger cohorts and exploring pharmacokinetic aspects of the microelements are called for.

Acknowledgments

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