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High Prevalence of Zinc Deficiency in Iranian Morbid Obese Patients Undergoing Bariatric Surgery

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Abstract

Background: Bariatric surgery's efficacy in morbid obesity therapy has been proven; but post-operational zinc deficiency is a problematic issue as its essential role in post-operational recovery of patients.

Objectives: The aim of this study is to evaluate the rate of zinc deficiency in Iranian morbidly obese candidates for bariatric surgery.

Patients and Methods: We assessed zinc status in 996 morbidly obese subjects (BMI > 40 kg/m^2 or BMI > 35 kg/m^2 with any comorbidities) (841 females, 155 males) who were candidate for bariatric surgery. Comorbidities related to obesity including dyslipidemia, abnormal fasting glucose, hypertension and type-2 diabetes (T2D) were evaluated. Also we checked albumin and SGPT as markers of liver function. Data analyzed by SPSS.

Results: Zinc deficiency was found in 13.6% of patients. Zinc levels had an inverse and significant association with age (P Value = 0.016). Although greater levels of circulating zinc were observed in patients with higher BMI, there were no significant correlation between zinc deficiency and adiposity. Dyslipidemia was found to be the most prevalent comorbidity in this population.

Conclusions: These results show a high prevalence of zinc deficiency in morbidly obese subjects. Thus, we suggest the evaluation of the zinc status in patients undergoing bariatric surgery and treatment of zinc deficiency before doing the surgery.

Keywords: Prevalence, Zinc Deficiency, Morbid Obese, Bariatric Surgery

1. Background

Obesity is a global major public health concern and is continuously growing worldwide (1). Obesity is found to be related to chronic diseases, such as cardiovascular disease, hypertension and diabetes mellitus, which puts a huge burden on health care systems (2). Nearly 312 million people are obese and 1.7 billion are overweight worldwide (3). In Iran the overall prevalence of obesity increased from 13.6% in 1999 to 19.6% in 2005 and 22.3% in 2007 (4).

Since lifestyle interventions are often unsuccessful in inducing adequate and sustained weight loss, bariatric surgery is the recommended procedure for treating morbid obesity, which helps patients retain their weight loss permanently (5). Popularity of bariatric surgery has been rising along with increasing the obesity prevalence in Iran (3). Since bariatric surgery changes the normal nutrients' absorption in intestinal tract, nutritional deficiencies are considered as postoperative consequences. (6-11). In addition, a high prevalence of distinct nutritional deficiencies has been observed in severely obese subjects before operation (9, 12-14). Data from the NHANES III including 3831 obese subjects indicated a higher likelihood of deficiencies in multiple micronutrient components in subjects with a body mass index (BMI) over 30 kg/m^2 as compared to normal-weighted subjects (13).

Zinc is a critical component in regulating gene expression, as well as humoral and cell-mediated immunity (15). Zinc deficiency commonly occurs following bariatric surgeries (16), while low serum zinc level before surgery is observed frequently (9, 12, 17, 18). On the other hand, data indicate a high prevalence of zinc deficiency in morbidly obese subjects (12).Decrease in consumption of foods rich in zinc, especially in obese patients, leads to increase the prevalence of zinc deficiency in obese subjects in comparison with normal-weighted people (19). Preoperational level of serum zinc in super obese patients is lower than healthy subjects (20, 21) and it might be a factor involved in zinc deficiency after surgery (22). Although nutritional deficiencies are common after bariatric surgery (9, 23), few studies have examined them preoperatively (24).

Since bariatric procedures such as gastric bypass and

sleeve gastrectomy are more popular in women in childbearing ages rather than men (16), investigating zinc status before bariatric surgery is of crucial importance because zinc deficiency is associated with adverse effects on pregnant women health and gestational outcomes, including hypertension (25), low birth weight, preterm infants and congenital disorders (26, 27). Moreover, it leads to clinical consequences specially infection and poor immunity which are more important for surgical recovery (28-30).

Prevalence of zinc deficiency is 17.3% and 15 - 20% globally, and in Iran (31) the rate of zinc deficiency in Tehranian healthy adults has been estimated to be around 2.5 - 3% (32). However, to the best of our knowledge, the rate of zinc deficiency before bariatric surgery, as being estimated in western studies, has not ever been investigated in Iran.

2. Objectives

The aim of this study is to evaluate the rate of zinc deficiency in Iranian morbidly obese candidates for bariatric surgery.

3. Patients and Methods

In this analytical cross sectional study, we assessed zinc status in all patients with a BMI of 40 kg/m^2 or higher, or a BMI of 35 kg/m^2 along with any comorbidity who were referred to four hospitals in Tehran (Hazrat-Rasoul, Moheb, Milad, Bahman) between 2007 and 2011 by census. The patients' height and weight were measured with patients wearing light cloths but no shoes. BMI was defined as weight (kg) divided by height squared (m^2). In all the patients, blood samples were drawn in the morning (8:00 – 9:00) after an overnight fasting. Zinc deficiency was defined as follows: serum zinc < 70 μg/dL. Since conditioned deficiency of zinc has been observed in patients with liver disease (12), in this study we measured some markers of liver function compromising comprising albumin and serum glutamic-pyruvic transaminase (SGPT). Data were analyzed by using SPSS 18 for Windows (SPSS, Chicago, IL, USA). To assess the influence of the degree of obesity, the subjects were grouped according to their BMI in three groups, i.e., BMI 35 - 40 kg/m^2, BMI40 - 50 kg/m^2 and BMI > 50 kg/m^2. The statistical significance was considered as a P Value less than 0.05 with a confidence interval of 95%. Unless otherwise indicated, data are reported as mean ± SD. Variables were compared between different BMI groups by χ^2 test for discrete variables and ANOVA for continuous variables. For pair wise comparisons, Student's t test or χ^2 test was used. Associations between zinc levels and BMI and age were evaluated by Pearson's correlation coefficient.

4. Results

The clinical characteristics of the study population are presented in Table 1. There were significant differences in age, weight and height across the gender. Interestingly, the median of evaluated BMI in men was higher than women but was not significantly different (P = 0.05).

There were 996 candidates for bariatric surgery, including 841 (84.4%) females and 155 (15.6%) males with mean age of 41.10 ± 10.82 and 35.35 ± 10.52 years, respectively. The mean preoperative body weight was 120.86 ± 22.18 kg (range, 64.2 - 224 kg) and the median of preoperative BMI was 43.63 kg/m^2 (range, 40.16 - 48.42 kg/m^2); the median BMI was 43.57 (40.10 - 48.18 kg/m^2) for females and 44.26 (40.36 - 50.31 kg/m^2) for males. The three main obesity related comorbidities were dyslipidemia in 454 (45.6%) patients, type 2 diabetes mellitus in 133 (13.4%) of the patients and hypertension in 182 (18.3%) patients (Table 1), among which dyslipidemia was the most prevalent comorbidity in all patients. The complete demographic data and patients' comorbidities are presented in Table 1.

Table 1. Participants Demographic Characteristics and Preoperative Comorbidities[a,b]

	Female	Male	P Value	Total
No. of patients	841 (84.4)	155 (15.6)	< 0.001	996 (100)
Age, y	41.10 ± 10.82	35.35 ± 10.52	< 0.001	40.20 ± 10.97
Weight, kg	116 ± 18.55	143.88 ± 25.86	< 0.001	120.86 ± 22.18
Height, cm	161.42 ± 6.39	176.71 ± 8.67	<0.001	163.80 ± 8.77
BMI median (IQR), kg/m^2	43.57 (40.10 to 48.18)	44.26 (40.36 to 50.31)	0.050	43.63 (40.16 to 48.42)
Comorbidities				
Dyslipidemia	391 (46.5)	63 (40.6)	0.003	454 (45.6)
Fasting glucose (100 <)	158 (22)	31 (20)	0.579	216 (21.7)
Hypertension	147 (17.5)	35 (22.6)	0.131	182 (18.3)
Type 2 diabetes	113 (13.4)	20 (12.9)	0.858	133 (13.4)

[a]Abbreviations: BMI: body mass index; IQR: interquartile range.
[b]Data are presented as mean ± SD or No. (%).

Comparison of data between men and women (Table 1) revealed that, as expected, men were significantly taller and heavier than women (P < 0.001), also men were older than women but BMI was similar among both sexes (P=0.05). Women displayed obesity related comorbidities, high fasting glucose, type 2 diabetes, hypertension and dyslipidemia, among which the last one was significantly higher in women. Dyslipidemia, Type 2 diabetes and hypertension have been related to zinc deficiency (9, 18).

According to BMI, 232 (23.3%) of patients were categorized as group 1 with a BMI of 35 – 40 kg/m², 569 (57.1%) as group 2 with a BMI of 35 - 40kg/m² and 195 (19.6%) as group 3 (BMI over 50 kg/m²) (Table 2). Table 2 provides data on zinc measured in the entire study population according to the BMI groups. Overall, below cut-off levels of zinc, i.e. zinc deficiency, were found in 13.6% of patients. The mean serum zinc level among all the patients was 94.95 ± 25.69 μg/dL (range, 12 - 174 μg/dL) and 95.35 ± 27.29 μg/dL (range, 14 - 169 μg/dL) in group 1, 95.71 ± 26.50 μg/dL (range, 13 - 178 μg/dL) in group 2 and 92.78 ± 22.57 μg/dL (range, 12 - 154 μg/dL) in the group 3; There was no significant difference in serum zinc levels among BMI groups (P Value = 0.639). There was no significant correlation between BMI and zinc concentrations (P Value = 0.135, r = −0.060). But There was significant correlation between age and serum zinc levels (P Value = 0.016, r = −0.097).

As shown in Table 2, the mean of serum zinc level was 95.09 ± 24.07 μg/dL (range, 13 - 149 μg/dL) in male subjects and 94.92 ± 26.03; 12 - 174 μg/dL in female subjects. Regarding gender, there was no significant difference in serum zinc levels (P Value = 0.953). In addition, The prevalence of zinc deficiency was defined as serum zinc level less than 70 μg/dL that was measured to be13.6% in all patients,14.2% in females and 10.6% in males (P Value = 0.325). Also, the prevalence of zinc deficiency was 13.3% in group 1, 14.5% in group 2 and 11.3% in group 3. There was no significant difference between zinc deficiency and groups of BMI (P Value = 0.605) (Table 2).

The greater rates of deficiencies were not related to an increasing BMI. Out of 966 patients, serum SGPT was measured in 814 and albumin in 616 patients. Normal levels of these tests have been shown in Table 3. Two hundred forty six patients (25.6%) had elevated SGPT and 12 patients (1.8%) had low serum albumin levels (Table 4). The mean of above tests for all patients and groups of BMI are showed in Table 4.

Table 2. The Mean and Prevalence of Zinc Deficiency in Females and Males and in Different Groups of Body Mass Index

Variables	Zinc Level μg/dL (n = 618) [a]	P Value	Prevalence of Zinc Deficiency, %	P Value
BMI		0.491		0.605
Group 1	95.35 ± 27.29; 14 - 169		(11.3)	
Group 2	95.71 ± 26.50; 13 - 178		(13.3)	
Group 3	92.78 ± 22.57; 12 - 154		(14.5)	
Gender		0.953		0.325
Female	94.92 ± 26.03; 12 - 174		(14.2)	
Male	95.09 ± 24.07; 13 - 149		(10.6)	
Total	94.95 ± 25.69; 12 - 174		(13.6)	

[a] Values are presented as mean ± SD.

Table 3. Normal Levels for Blood Tests[a]

Test	Ref.Value	Prevalence of Blood Test Abnormalities [b]
SGPT		246 (25.6)
Female	7 - 30	
Male	10 - 55	
Albumin	3.5 - 5.5	12 (1.8)

[a] Abbreviation: SGPT: serum glutamic-pyruvic transaminase.
[b] Values are presented as No. (%).

Table 4. Mean and Prevalence of Blood Test Abnormalities Based on Groups of Body Mass Index[a,b]

Test	BMI, kg/m²			P Value [c]	Total
	35 - 39.99	40 - 49.99	> 50		
SGPT, U/L: (n = 962)	30.17 ± 23.80	30.74 ± 24.73	34.20 ± 73.85	0.516	31.28 ± 39.22
Albumin, g/dL (n = 662)	4.28 ± 0.6	5.49 ± 19.64	4.22 ± 0.53	0.611	5.03 ± 15.64

[a] Values are presented as mean ± SD.
[b] Abbreviations: BMI: body mass index; SGPT: serum glutamic-pyruvic transaminase.
[c] P Value derived from parametric ANOVAT test.

Considering liver function, SGPT concentrations was greater in the BMI groups of > 50 kg/m^2 than in the other BMI groups; however no differences were found for SGPT levels according to the BMI. The frequency of lower albumin was greater in the BMI group of 40 - 50 kg/m^2 than in the other BMI groups. Considering zinc deficiency, no differences were found among the groups. Although higher zinc deficiency were found in the BMI group of 40 - 50 kg/m^2 than the other BMI groups. By analyzing the absolute values, no differences were found in the serum zinc levels with an increasing BMI.

5. Discussion

The present data indicate a high prevalence (> 10%) of zinc deficiency as well as elevated SGPT abnormalities in morbidly obese patients (BMI ≥ 35 kg/m^2). The high prevalence of zinc deficiency in our study agrees with the findings from previous studies of obese patients in the setting of before bariatric surgery (9, 12, 16, 24). Deficiency of zinc could be explained in obese patients, if the accumulation of adipose tissue increases the production of adipocytokines, which result in a chronic inflammatory process. The inflammation induces the expression of metallothioein and zinc-copper transporter in hepatocytes. These proteins promote metal accumulation in the liver and in adipocytes, which might have contributed to low zinc concentrations (18). Furthermore marginally low intake of high content zinc resources is another reason for this deficiency (33). This could explain the high prevalence of zinc deficiency in our morbidly obese patients. The other important reason of high rates of zinc deficiency is the lack of food fortification by zinc in Iran except for some limited brands of cookies for school children.

In addition low prevalence rates (< 5%) of abnormalities were found for albumin, the zinc transporter protein in blood, which is in contrary with previous studies that found higher rates of low levels of albumin. Although the highest BMI group had the lowest serum albumin in previous study (12), we found highest serum albumin in highest BMI group while no association was observed between serum albumin and adiposity in our study.

Zinc deficiency and liver dysfunction has been correlated in previous studies so that, zinc deficiency could participate in liver diseases and the liver exerts a critical role in zinc homeostasis (34). Although in our study both zinc deficiency and abnormal levels of SGPT were high, it was not observed any significant association neither between obesity and zinc deficiency nor between obesity and SGPT as a marker of liver dysfunction (P = 0516).

Although some studies found a negative relation between zinc deficiency and BMI (35), some studies have shown that preoperative serum zinc is not related to BMI in bariatric candidates (16, 17, 36). In our study, as expected, lower levels of serum zinc were within the highest BMI group (> 50 kg/m^2) while zinc deficiency was not related to an increasing BMI.

The limitations of the previous studies and our design could explain these contradictory data. First, our study population was recruited from patients referred to our interdisciplinary obesity center for obesity treatment. Therefore, results obtained here should not be generalized to a population-based level. Second, deficiency in zinc may depend on cultural and geographical factors, thus, our findings cannot be generalized to other cultures and geographical regions. Third, our study was a cross-sectional study, which prevented us to draw conclusions directly about the relationship of this deficiency and BMI. Forth, differences in distribution of participants in BMI categories could have altered the results. For example, the second group of BMI has the biggest numbers of patients comparing to the other two groups. Fifth, these deficiencies depend on geographic factors which were not controlled in our study design. For example, the soil in the region could be poor in zinc. Sixth, the dietary intake was not controlled and it remains unclear whether the observed zinc deficiencies emerge from an inadequate intake, nutritional habits or other factors. For example, a low intake of meat could explain the high rate of zinc deficiency. Finally, the serum zinc value might not be a sensitive marker for deficiency, and we could have underestimated this prevalence; erythrocyte zinc levels could be more accurate. This data suggest the evaluation of other micronutrient deficiencies among Iranian morbid obesity cases in the preoperative setting.

The high prevalence of zinc deficiency indicated in morbidly obese candidates before bariatric surgery, might lead to a poorer recovery in the postoperative period. These data shows high prevalence of zinc deficiency among morbidly obese Iranian patients seeking obesity surgery. Since zinc deficiency in the field of bariatric surgery has been seen frequently postoperatively, so baseline assessment of zinc deficiency before surgery would be reasonable without which attributing this deficiency solely to the bariatric procedure is impossible. The prevention or correction of detected zinc deficiencies before operation by beginning supplementation could alleviate the deficiency rate after surgery. Taking into account, more studies are needed to investigate the zinc deficiency related diseases in morbidly obese patients. Therefore a preoperative evaluation of circulating zinc and the food intake evaluation is recommended for these patients as well as zinc supplementation, if needed.

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