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Original article

Nutrient deficiencies in patients with obesity considering bariatric surgery: a cross-sectional study

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Abstract

Background: Nutritional deficiencies are common after bariatric surgery, but few studies have examined them preoperatively. The objective of this study was to evaluate several vitamins, nutrients, and nutritional markers and their determinants in patients with obesity considering bariatric surgery.

Methods: Preoperative values of fasting plasma glucose, insulin, lipid profile, 25-hydroxyvitamin D (25(OH)D), parathyroid hormone, thyroid-stimulating hormone, calcium, phosphate, albumin, magnesium, total proteins, liver function tests, iron, ferritin, folate, vitamin A, vitamin B12, selenium, and zinc were evaluated in 267 Caucasian outpatients (74.2% women, aged 40.5 ± 12.6 years) who were considering bariatric surgery. The determinants of nutrient variability were analyzed by linear regression for nutrients with a prevalence of deficiency $>10\%$, i.e., serum 25(OH)D, iron, phosphate, magnesium, and vitamin A.

Results: Prevalence of inadequate concentrations was high for 25(OH)D (67.9% with values ≤ 20 ng/mL), magnesium (35.4%), phosphate (21.6%), iron (18.8%), and vitamin A (16.9%). Multiple deficiencies were common; 28.5%, 12.1%, and 6.3% of patients had 2, 3, and 4 deficiencies, respectively. In multivariate analyses, metabolic characteristics had an important impact on deficiencies, with lower values of 25(OH)D and vitamin A with increasing body mass index, lower values of 25(OH)D and magnesium with increasing fasting plasma glucose, and a positive correlation between vitamin A and triglycerides. Elevated TSH was associated with low iron concentrations.

Conclusion: At all ages, micronutrient deficiencies were common, with high prevalence of concentration inadequacies for 25(OH)D, magnesium, phosphate, iron, and vitamin A. High body mass index and high fasting plasma glucose increased the risk of deficiencies, particularly for 25(OH)D. Preoperative screening and correction of deficiencies should be advised. (Surg Obes Relat Dis 2014;▮:00-00.)

Keywords: Vitamin D; Obesity; Bariatric surgery; Fasting plasma glucose; Parathyroid hormone

Several nutritional deficiencies can occur after bariatric surgery, particularly after malabsorptive procedures [1]. Deficiencies of several nutrients, including iron, folate, 25-hydroxyvitamin D (25(OH)D), and vitamin B12 have been well documented [1]. Related adverse clinical outcomes, such as anemia and neurologic complications, have been reported, and concerns about the long-term effects of bariatric surgery on bone metabolism have been raised. Moreover, 25(OH)D deficiency has been associated with an increased morbidity that goes beyond bone metabolism, including higher prevalences of cancer and cardiovascular

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diseases [2]. Given the increasing prevalence of obesity and bariatric surgery procedures, underdiagnosing nutritional deficiencies may lead to an increasing number of significant clinical complications.

Although many studies have evaluated nutritional deficiencies after bariatric surgery, few have examined the preoperative nutritional status of patients with obesity [3–7]. Considering the high rate of bariatric surgery patients who are reluctant to accept long-term postoperative follow-up, the preoperative period is crucial for information and prevention regarding clinical consequences of nutritional deficiencies. Here we report an extensive preoperative evaluation of several vitamins and minerals in 267 consecutive patients considering bariatric surgery, with a special focus on the most frequent deficiencies and their determinants.

Methods

Study patients and design

This cross-sectional study evaluated 267 Caucasian outpatients admitted for medical assessment before bariatric surgery in Montpellier University Hospital from March 4, 2007 to January 7, 2010. Patients had a body mass index (BMI) >35 kg/m^2 and were not taking vitamins or minerals supplements. The study was approved by the Technical Committee of the Clinical Investigation Centre of Montpellier University Hospital.

Procedures

Patients attended the unit after a 12-hour fast. BMI was calculated as the mean weight (kg) divided by the mean height squared (m^2). Waist circumference was measured at midpoint between iliac crest and lower ribs. Fat mass was measured by multifrequency bio-impedance analysis (Body Impedance Analyzer 101/S RJL system, Clinton Township, MI). Blood was drawn for determination of fasting parameters, then patients were administered a 75-g oral glucose load and blood glucose was measured 120 minutes after glucose intake.

Analytical parameters

Evaluation of patient health status included determination of lipid profile, hemoglobin, ferritin, creatinine, albumin, liver function tests, thyroid-stimulating hormone (TSH), and parathyroid hormone (PTH).

The following micronutrients concentrations were evaluated: 4 vitamins (i.e., 25(OH)D, vitamin A, vitamin B12, folates) and 6 minerals (i.e., iron, calcium, phosphate, magnesium, selenium, and zinc). 25(OH)D concentrations were categorized as adequate (>20 ng/mL), insufficient (12–20 ng/mL), or deficient (<12 ng/mL), based on the report of the Institute of Medicine [8]. Thresholds for other deficiencies were: <1.63 μmol/L for vitamin A, <150 pmol/L for vitamin B12, <400 nmol/L for red blood cells (RBC) folate, <9.5 μmol/L (men) and <8.8 μmol/L (women) for iron, <2.02 mmol/L for corrected serum calcium, $<.84$ mmol/L for phosphate, $<.8$ mmol/L for magnesium, $<.76$ μmol/L for selenium, and <10 μmol/L for zinc. The frequency of multiple deficiencies was evaluated. All laboratory assays were performed in Montpellier University Hospital central laboratory.

Calculated parameters

Corrected serum calcium (mmol/L) was calculated using (1) albumin: measured serum calcium (mmol/L) – .025 (albumin [g/L] – 40) or (2) protein: measured serum calcium (mmol/L)/(.55 + proteins [g/L]/160). Renal function was estimated according to the Modification of Diet in Renal Disease (MDRD) formula, i.e., $186.3 \times$ (serum creatinine [μmol/L]/88.4)$^{-1.154} \times$ age$^{-.203}$ ($\times$ .742 for women).

Definitions

Metabolic syndrome was defined according to the National Cholesterol Education Program Adult Treatment Panel III [9]. Hyperparathyroidism was defined as a PTH concentration >62 pg/mL.

Statistical analyses

A first analysis was performed on the total sample ($n = 267$). Patients' characteristics and prevalence of micronutrients and proteins abnormalities were presented using median and interquartile range (or mean and standard deviation) for continuous variables and frequencies and proportions for categorical variables. Relationships between continuous parameters were assessed using the Spearman correlation coefficient and adjusted using the partial Spearman correlation coefficient.

The determinants of nutrients variability were analyzed for micronutrients with a prevalence of deficiency $>10\%$, i.e., serum 25(OH)D, iron, phosphate, magnesium, and vitamin A. To avoid interferences of diabetes treatment on glucose and insulin concentrations, these analyses were performed in the subset of $n = 217$ patients without known diabetes at baseline. Univariate linear regression models were used first. When necessary, variables were transformed to ensure a Gaussian distribution of the residuals of the regressions. Multivariate linear regression models were then used to evaluate independent variables explaining the variability of nutrients. In the multivariate model, the issue of missing values was addressed by carrying out data imputation on both outcome variables and covariates. Multiple imputation by the Markov chain Monte Carlo method was used [10] (MI and MIanalyze Procedures implemented in SAS V9) [11]. The imputed data set was