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Copper, selenium and zinc levels after bariatric surgery in patients recommended to take multivitamin-mineral supplementation

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ABSTRACT

Background: Bariatric surgery is widely performed to improve obesity-related disorders, but can lead to nutrient deficiencies. In this study we examined serum trace element concentrations before and after bariatric surgery.

Methods: We obtained serum trace element concentrations by inductively coupled plasma-mass spectrometry (ICP-MS) method in 437 patients (82% women, median preoperative body-mass index 46.7 kg/m^2 [interquartile range 42–51]) undergoing either gastric banding (22.7%), sleeve gastrectomy (20.1%), or gastric bypass (57.3%) procedures. Trace element data were available for patients preoperatively ($n = 44$); and 3 ($n = 208$), 6 ($n = 174$), 12 ($n = 122$), 18 ($n = 39$), 24 ($n = 44$) and 36 months ($n = 14$) post-operatively. All patients were recommended to take a multivitamin-mineral supplement after surgery.

Results: Copper deficiency was found in 2% of patients before surgery; and after surgery deficiency rates ranged from 0 to 5% with no significant change in median concentrations during follow-up ($p = 0.68$). Selenium deficiency was reported in 2% of patients before surgery; and after surgery deficiency rates ranged from 11 to 15% with a near-significant change in median concentrations ($p = 0.056$). Zinc deficiency was reported in 7% before surgery; and after surgery deficiency rates ranged from 7 to 15% with no significant change in median concentrations ($p = 0.39$).

Conclusions: In bariatric surgery patients recommended to take multivitamin-mineral supplements, serum copper, zinc and selenium concentrations were mostly stable during the first years after bariatric surgery. There was a possible tendency for selenium concentrations to decline during the early postoperative period.

Introduction

Obesity is an increasingly prevalent worldwide health problem. The prevalence of the disorder in adults has more than tripled in the past decade, and obesity currently affects approximately 20–35% of the general population in the developed world [1,2]. Obesity is a major contributor to some of the leading causes of death in the developed world, including heart disease, stroke, type 2 diabetes mellitus (T2DM) and some types of cancer [2].

Bariatric surgery has been shown to be the most effective treatment for morbid obesity and its associated co-morbidities such as T2DM, both in large well-matched clinical studies and randomized controlled trials (RCTs) [3–9]. Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG) and the adjustable gastric band (AGB) are the most commonly performed surgical procedures. The RYGB procedure typically involves fashioning a 15- to 20-mL gastric pouch and creating a large new outlet that rapidly empties into the mid small intestine. It causes 25–30% weight loss, which is maintained for at least 20 years [10,11]. The AGB is a silastic band positioned laparoscopically around the upper portion of the stomach. The volume of fluid in the band is adjusted through injections in a subcutaneous port. The procedure results in 20–25% long-term weight loss [10,12]. Sleeve gastrectomy is a longitudinal resection leaving a gastric pouch of approximately 100 mL that remains connected to the duodenum. The SG was initially performed as part of the

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duodenal switch procedure, but it is now gaining popularity as a stand-alone procedure that can cause a weight loss of 20–30% in the long term [10,13].

Despite the success of bariatric procedures, nutrient deficiencies are among the most common postoperative complications [14]. Multiple reasons have been proposed to explain the vitamin deficiencies after bariatric procedures. Nutritional deficiencies may occur in some bariatric surgery patients due to preoperative deficiencies which are not repleted prior to surgery as well as due to reduced food intake and reduced absorption of vitamins in the gastrointestinal tract post-surgery [14]. Deficiencies in vitamin B_{12}, folate and iron are not uncommon early after bariatric surgery and calcium, vitamin D and trace element deficiencies can also occur after bariatric procedures [14].

Deficiency in trace elements postoperatively is not something unexpected, especially after RYGB as selenium and zinc are absorbed in the duodenum and proximal jejunum and copper is absorbed in the stomach and proximal duodenum [15]. Severe selenium deficiency can cause symptoms and diseases including myopathy, cardiomyopathy, arrhythmia, muscle wasting, impaired immunity, low thyroid function, loss of skin and hair pigmentation, whitened nail beds, and progressive encephalopathy [15,16]. On the other hand, zinc deficiency has been reported to cause diarrhoea, emotional disorders, weight loss, intercurrent infection, bullous-pustular dermatitis, and hypogonadism in males [15,17]. Finally, copper deficiency in adults can manifest in hematologic and neurologic symptoms, and cases of normocytic anaemia, myelopathy and myeloneuropathy related to copper deficiency after bariatric procedures have been described [15,18–22].

Few studies have reported selenium, zinc and copper levels post-bariatric procedures and some of them have confirmed deficiency in some of the trace elements [23–25]. Despite this, the available data on the changes in trace elements levels post-bariatric surgery is very limited.

The primary objective of this study will be to evaluate the changes on trace element status in morbidly obese patient who have undergone bariatric procedures as well as to document the prevalence of trace elements deficiency preoperatively and post-bariatric surgery.

Materials and methods

A retrospective review of a prospective collected database was performed. Four hundred thirty seven patients who were planned for or had already received a bariatric operation and they had at least one measurement of trace elements at one time point preoperatively or postoperatively were included. The study was approved by the Local Clinical Governance and Patient Safety committee at Imperial College (ICHNT 09/612).

All the patients qualified for bariatric surgery according to the NIH Consensus Development Panel on Gastrointestinal Surgery for Severe Obesity criteria [26]. The bariatric procedures that were performed for these patients were RYGB, AGB or SG. The patients had measurement of the trace metals as part of their routine preoperative and follow-up blood tests at 3, 6, 12, 18, 24 and 36 months. The trace elements that were measured at the laboratories were copper, zinc and selenium. Trace elements deficiency was defined as serum trace element level below the lower reference level (Table 1). All patients were advised to take a daily multivitamin-mineral supplementary postoperatively (one capsule daily). The multivitamin-mineral supplement recommended to the patients (Forceval Adult Capsules, UK) contained 50 μg selenium, 15 mg of zinc, and 2 mg of copper per capsule alongside other vitamins and minerals (Table 2). During each follow-up consultation, the patients were encouraged to take daily their supplements.

Serum samples were collected in plastic blood collection tubes designated for trace element analysis (BD vacutainer with Na heparin, BD, Oxford, UK). Samples were stored refrigerated until analysis (analysis was performed during the first 10 days since sample collection). Serum selenium, copper and zinc levels were measured at the Department of Biochemistry at Charing Cross Hospital, Imperial College Healthcare NHS Trust with the inductively coupled plasma-mass spectrometry (ICP-MS) method.

Serum samples were diluted 1:40 in a solution containing 2.5% (v/v) tetramethylammonium hydroxide, 1% (v/v) n-butanol, 0.001% (v/v) Triton X-100 (Romil, Cambridge, UK), and 1 μg/L gallium as internal standard. Analysis was performed with a quadrupole inductively coupled plasma mass spectrometer with a concentric glass nebulizer and cyclonic spray chamber (DRCII; Perkin-Elmer, Waltham, MA, USA). The instrument was used in dynamic reaction cell mode with ammonia as reaction cell gas. Isotopes monitored were 64Zn, 66Zn, 63Cu, 65Cu, 78Se, 80Se, and 71Ga. Two isotopes for each of the elements were measured to assure the accuracy of the results. The agreement between the two isotopes for zinc and copper was <2% and for selenium <5%. Certified quality control samples (Clinchek, RECIPE Chemicals + Instruments GmbH, Munich, Germany) were used to assure the accuracy of the analysis. The laboratory participates in the United Kingdom National External Quality Assessment Service (UKNEQAS) for trace elements.

Statistical analysis

Mean, median values and % percentages were used for descriptive statistics and for the trace elements values and deficiencies as appropriate. A Kruskal–Wallis ANOVA test was used to evaluate the change of selenium, copper and zinc median concentrations during the first 3 years postoperatively. A $p < 0.05$ was considered significant for all analyses. If the Kruskal–Wallis test was significant, a

Table 1
Serum trace element reference range.

Copper	μmol/L	12.0–20.0
Zinc	μmol/L	10.0–18.0
Selenium	μmol/L	0.75–1.85

Table 2
Multivitamin – minerals daily supplement.

Nutrient	Unit	Multivitamin
Vitamin A (as β-Carotene)	IU	2500.0
Vitamin D2 (Ergocalciferol)	IU	400.0
Vitamin B1 (Thiamine)	mg	1.2
Vitamin B2 (Riboflavin)	mg	1.6
Vitamin B6 (Pyridoxine)	mg	2.0
Vitamin B12 (Cyanocobalamin)	μg	3.0
Vitamin C (Ascorbic acid)	mg	60.0
Vitamin E (DL-α-Tocopheryl acetate)	mg	10.0
d-Biotin (Vitamin H)	μg	100.0
Nicotinamide (Vitamin B3)	mg	18.0
Pantothenic acid (Vitamin B5)	mg	4.0
Folic acid (Vitamin B complex)	μg	400.0
Calcium	mg	100.0
Iron	mg	12.0
Copper	mg	2.0
Phosphorus	mg	77.0
Magnesium	mg	30.0
Potassium	mg	4.0
Zinc	mg	15.0
Iodine	μg	140.0
Manganese	mg	3.0
Selenium	μg	50.0
Chromium	μg	200.0
Molybdenum	μg	250.0

Nutrients per capsule (Forceval Adult Capsules, UK).
IU: International Units, mg: milligramme, μg: microgram.