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Changes in Urinary Iodine Levels Following Bariatric Surgery

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Abstract

Objective: Obesity has become an epidemic in the United States. Although bariatric surgery can effectively achieve weight loss by altering the gastrointestinal tract, it commonly results in micronutrient deficiency, requiring supplementation. Iodine is an essential micronutrient for the synthesis of thyroid hormones. We aimed to investigate changes in urinary iodine concentrations (UIC) in patients following bariatric surgery.

Methods: 85 adults who underwent either laparoscopic sleeve gastrectomy or laparoscopic Roux-en-Y gastric bypass surgery were enrolled. At baseline and 3 months after surgery, we evaluated spot UIC and serum thyroid stimulating hormone (TSH), vitamin D, vitamin B12, ferritin, and folate levels. Participants provided a 24-hour diet recall for iodine-rich foods and information about multivitamin use at each time point.

Results: There was a significant increase in median UIC (201 [120.0 – 288.5] vs. 334.5 [236.3 – 740.3] μg/L; $p < 0.001$), a significant decrease in mean body mass index (BMI) (44.0 ± 6.2 vs. 35.8 ± 5.9; $p < 0.001$) and a significant decrease in TSH levels (1.5 [1.2 – 2.0] vs. 1.1 [0.7 – 1.6]

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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uIU/mL; $p < 0.001$) at 3 months postoperatively compared to baseline. BMI, UIC, and TSH levels before and after surgery did not differ based on the type of weight loss surgery.

Conclusion: In an iodine-sufficient area, bariatric surgery does not cause iodine deficiency nor clinically significant changes in thyroid function. Different surgical procedures with different anatomical alterations in the gastrointestinal tract do not significantly affect iodine status.

Keywords

Urinary iodine; obesity; bariatric surgery; micronutrients; thyroid function

Introduction

Obesity has become an epidemic in the United States. Nearly one in two U.S. adults will have obesity, and one in four adults will have class II obesity by 2030 (1). Bariatric surgery is by far the most effective intervention for sustained weight loss via restrictive, malabsorptive, or a combination of both mechanisms (2). Sleeve gastrectomy and Roux-en-Y gastric bypass procedures are the most frequently performed surgeries in the United States (2). However, bariatric surgery can result in multiple nutritional deficiencies due to altered digestion and absorption (2, 3). It is recommended that all post-bariatric-surgery patients take oral multivitamin supplements to prevent micronutrient deficiency (2, 3).

Iodine is a critical micronutrient for producing thyroid hormones. Significant dietary sources of iodine include iodized salt, dairy products, eggs, seafood, fish, and seaweed (4). Iodine absorption occurs primarily in the proximal small intestine via sodium-iodine symporter (5). Approximately 90% of the ingested iodine eventually appears in the urine (6). Urinary iodine concentration (UIC) is the most commonly used indicator to assess iodine status (7). Although UIC is not a reliable biomarker for individuals' iodine status due to very high day-to-day variation (8), spot median UIC can be used to assess population iodine status (9).

Prior studies of iodine status after bariatric surgery have shown conflicting results. In 1964, the first observational study reported that 6 of 8 total gastrectomy patients, despite adequate dietary iodine intake, had evidence of iodine deficiency based on low 24-hour UIC and plasma inorganic iodine levels (10). Since then, only a few studies have specifically evaluated changes in iodine status after bariatric surgery, but none have demonstrated postoperative iodine deficiency (11–13). The 2016 guideline for micronutrients by the American Society for Metabolic and Bariatric Surgery did not address iodine (3). Concomitant deficiencies in micronutrients such as selenium, iron, and vitamin A can further worsen the effects of iodine deficiency by impairing thyroid hormone synthesis (14). Whether altered gastrointestinal anatomy and physiology leads to iodine deficiency in patients undergoing bariatric surgery remains uncertain.

We aimed to investigate the changes in urinary iodine levels in patients following bariatric surgery. We hypothesized that bariatric surgery, especially the Roux-en-Y gastric bypass procedure, may result in iodine deficiency since iodine absorption occurs primarily in the small intestine. If post-bariatric surgery patients are at risk for iodine deficiency, this could affect thyroid function and thyroid hormone metabolism.

Methods

Study Design and Patients

In this prospective observational cohort study, we enrolled participants aged 18 years or older scheduled for elective bariatric surgery (laparoscopic sleeve gastrectomy or laparoscopic Roux-en-Y gastric bypass) at a tertiary safety-net academic medical center in New England, between January 2014 and July 2016. This tertiary hospital in an iodine-sufficient region (15) serves diverse ethnic groups. Exclusion criteria were current use of amiodarone or other iodine-containing medications (apart from multivitamins) or prior use within the past 2 years, exposure to iodinated contrast in the past 6 months, use of lithium in the past 3 months, known history of thyroid dysfunction, and being actively treated with thyroid hormone or anti-thyroid drugs.

Eligible participants were approached at the preoperative bariatric surgery clinic. All participants provided informed consent before enrollment. Subjects served as their own controls. Follow-up was planned at 3 and 6-months postoperatively, but due to the high loss-to-follow-up rate at 6 months after surgery, only data from the 3-month timepoint were analyzed. The Boston University Institutional Review Board approved this study (project number H32665).

Data Acquisition

At baseline, we collected demographic information, including age, gender, race, and insurance type (as a surrogate for socioeconomic status). Weight and height were used to calculate body mass index [BMI = (weight in kilograms) ÷ (height in meters)^2]. At baseline and at 3 months postoperatively, each participant provided a random spot urine sample. Serum was drawn at each time point to measure TSH, 25-hydroxy vitamin D, vitamin B12, ferritin, and folate. A questionnaire ascertaining multivitamin use and consumption of iodine-rich foods, such as iodized salt, milk, cheese, and yogurt, in the past 24 hours was administered at each time point.

Laboratory Methods

UIC was measured spectrophotometrically by the Sandell-Kolthoff reaction following chloric acid digestion (Technicon Instrument, Inc, Tarrytown, NY), a modification of the method of Benotti et al (16). Iodine concentrations from each sample were measured twice, and the values were averaged. Adequate iodine intake was defined as a median UIC 100 – 199 μg/L for the non-pregnant adult population, according to World Health Organization (WHO) criteria (7). Serum TSH, 25-hydroxy vitamin D, vitamin B12, ferritin, and folate levels were measured at hostpial’s clinical laboratory. Reference ranges for each laboratory measurement were used to define nutrient deficiency or sufficiency. Values within and above the reference range were classified as sufficient, while those below the reference range were deficient. The reference range for TSH was 0.35 – 4.9 uIU/mL, 25-hydroxy vitamin D 30 – 100 ng/mL, vitamin B12 213 – 816 pg/mL, ferritin 10 – 109 ng/mL, and folate 5.8 – 31.4 ng/mL.

Outcomes

The primary outcome was change in UIC after bariatric surgery from baseline. The secondary outcome was change in thyroid function, measured by serum TSH.

Statistical Analysis

Data are presented as means ± standard deviations (SD) for normally distributed variables, medians with interquartile ranges for nonnormally distributed variables, and frequencies for categorical variables. For comparisons among study groups, normally distributed variables were assessed using the Student's T-test in paired comparisons. For variables that failed the normality test, pairwise comparisons were performed using the Mann-Whitney rank sum test. Pearson's Chi-square test was used to compare ratios between groups. A two-sided P value < 0.05 was considered statistically significant. All statistical analyses were performed with SPSS software, version 23.0 (IBM, Armonk NY).

Results

A total of 85 participants were included in this study. Participants underwent either sleeve gastrectomy (n = 59, 69.4%) or Roux-en-Y bypass surgery (n = 25, 29.4%). Participants' characteristics at baseline and 3 months after surgery are presented in Table 1. Although 85 recruited subjects completed the baseline assessment before bariatric surgery, only 62 participants could be reached for follow up at 3 months postoperatively. Most enrolled participants were female (85.9%) with diverse races/ethnicities (35.3% Caucasian, 25.9% Black, 37.7% Hispanic) and had public insurance (Medicare/Medicaid; 68.2%). The mean BMI decreased from 44.0 ± 6.2 kg/m^2 at baseline to 35.8 ± 5.9 kg/m^2 three months after surgery.

The median UIC increased from the baseline of 201 (120.0 – 288.5) μg/L to 334.5 (236.3 – 740.3) μg/L at 3 months postoperatively ($p < 0.001$) (Table 2). No significant difference in UIC at 3 months between subjects who followed up at 6 months (360.0 [276.0 – 856.0] μg/L) and those who did not (327 [222.5 – 690.0] μg/L) ($p = 0.17$). The median TSH level decreased from 1.5 (1.2 – 2.0) uIU/mL to 1.1 (0.7 – 1.6) uIU/mL ($p < 0.001$) (Table 2). The 24-hour dietary recall for iodine-rich food and dietary supplements demonstrated a significant increase in use of multivitamin and dietary supplement intake after surgery ($p < 0.001$), but consumption of iodine-rich foods, such as table salt, seaweed, dairy, soy milk, egg, bread, bagel, fish or shellfish, did not change (Table 3). Among other measured micronutrients, only 25-hydroxy vitamin D significantly increased after bariatric surgery. At baseline, 92.8% of participants were deficient in vitamin D, but 50% of participants became vitamin D sufficient 3 months after surgery ($p < 0.001$). More than 90% of participants had sufficient vitamin B12, ferritin, and folate levels before and after surgery without significant postoperative changes (Table 2).

There were no significant differences between BMI, UIC, and TSH levels at baseline and 3 months after surgery between subjects who underwent laparoscopic gastric bypass and those who underwent laparoscopic Roux-en-Y bypass (Table 4).

Discussion

We used a prospective observational cohort to assess changes in urinary iodine concentrations in patients with obesity before and after bariatric surgery in an iodine-sufficient area. In our study, UIC increased 3 months after surgery compared to baseline. Patients who underwent bariatric surgery in our cohort did not experience iodine deficiency postoperatively.

Our finding of iodine sufficiency following bariatric surgery supports results from recent studies conducted in Greece, Spain, and Sweden, which are iodine-sufficient countries (14). Our study findings are similar to the study published by Michalaki et al., which included 35 patients who underwent Roux-en-Y or a variant of biliopancreatic diversion in Greece (11). Similar to our study design, patients in that study were evaluated at baseline, and at 3- and 6-months postoperatively. There was an increase in UIC level at 3 months after surgery, followed by a return close to baseline levels 6 months postoperatively regardless of surgery type. However, information regarding multivitamin use or iodine supplementation was not reported in that study.

Lecube et al. reported on 90 women in Spain who underwent either sleeve gastrectomy or Roux-en-Y bypass surgery, with follow-ups ranging from 18 months to 5 years (12). All patients were discharged on a daily multivitamin for one month after surgery. Women with obesity, compared to non-obese controls, had a higher rate of iodine deficiency at baseline. Based on dietary questionnaires, the difference in baseline UIC was thought to be related to preferred dietary choices. UIC increased after bariatric surgery and remained stable.

The Swedish Obese Subjects (SOS) Study is by far the largest study to date, with the longest follow-up duration (13). Very few patients (0 – 9%) took iodine supplementation. This study compared 188 Roux-en-Y gastric bypass patients, 188 vertical banded gastroplasty patients, and 188 patients with obesity to population-based controls. At baseline, UIC was higher in the groups with obesity than in the population-based controls. Ten years after surgery, UIC in the surgical groups became similar to that in the population-based controls but was lower than in the patients with obesity but without surgery.

In contrast to the 1964 study by Harden et al. that reported iodine deficiency in 6 of 8 patients who underwent total gastrectomy (13), none of these more recent studies have demonstrated postoperative iodine deficiency. This discrepancy may be due to improvement in dietary iodine intakes over the last several decades in most regions, improvement in routine vitamin supplementation after weight loss surgery, the small sample size of the initial study, or differences in iodine status assessment.

Similar UIC between patients following different bariatric procedures

Our study did not find a significant difference in UIC following sleeve gastrectomy compared to Roux-en-Y gastric bypass. Our result aligned with the study by Lecube et al. (12) comparing these two procedures. The sleeve gastrectomy is a purely restrictive procedure that removes the greater curvature of the stomach. Mechanical digestion is reduced with a smaller stomach size and lower gastric juice secretion. Roux-en-Y surgery, involving more anatomical alterations, is a restrictive and malabsorptive procedure. The small gastric pouch contributes to food restriction. Food bypasses the excluded stomach and duodenum, and the increased length of the roux limb creates macronutrient and micronutrient malabsorption (2). Michalaki et al. also reported similar UIC following two surgical interventions, Roux-en-Y and a variant of biliopancreatic diversion (11). The biliopancreatic diversion, which is now rarely performed, involves both restriction of caloric intake and malabsorption (2). In the SOS Study, when comparing vertical banded gastroplasty with Roux-en-Y gastric bypass, UIC decreased similarly in both groups from baseline to 10 years after surgery and remained similar to the non-obese control group (13). The vertical banded gastroplasty is a restrictive surgery that is no longer performed. Based on these findings, the extent of anatomical alterations from different surgical interventions does not appear to affect intestinal iodine absorption.

Possible mechanisms for maintaining iodine sufficiency following bariatric surgery

It is challenging to explain why there was an increase of UIC three months after surgery in our study. Based on the UIC results at 3 months after surgery, it is notable that the iodine intake in participants may have exceeded the recommended intake or even reached excessive levels. In addition to possible lack of effect on intestinal iodine absorption after surgery, we propose a few possible explanations for the results of our study and that of Michalaki et al. (11). First is the recommended use of multivitamin supplements postoperatively, although not all the available multivitamin formulations on the market contain iodine (17). The second possible explanation is change in diet. One recent study showed that postoperative dietary iodine intake was significantly higher in the first month compared to 3 and 6 months after sleeve gastrectomy (14). Significant dietary modification is required during the acute postoperative period due to a smaller stomach. Although the consistency of the diet usually returns to normal soon after surgery, early satiety may encourage patients to consume more soft or liquid dairy products, and dairy is one of the major iodine sources in the United States (15). However, we observed a non-significant decrease in the consumption of iodine-rich foods (Table 3). This finding suggests that the increase in urinary iodine concentration (UIC) postoperatively was likely driven by iodine from supplements rather than dietary sources.

Changes in TSH levels following bariatric surgery

Changes in serum TSH levels postoperatively were correlated with the change in BMI. Median TSH levels decreased at 3 months postoperatively. A bidirectional relationship between obesity and thyroid function has already been established (18). Hypothyroidism can cause weight gain, while obesity, in turn, affects thyroid function. A high proportion of patients (18.1%) evaluated for bariatric surgery had elevated serum TSH (19). BMI has been found to be positively associated with TSH levels, and weight loss may normalize TSH. This may be due, at least in part, to regulation by leptin secreted by adipose tissue, as leptin stimulates the hypothalamus and ultimately increases TSH release (20).

Limitations

Our study has several limitations. The sample size was small, and we did not meet recruitment target. Given the small sample size, we could not perform stratified analyses for ethnicity and insurance types to evaluate potential impact of ethnicity or socioeconomic status. The loss to follow-up was high after surgery. Several factors likely contributed to the loss of patients during the follow-up period. These include the absence of incentives or compensation, diminishing patient motivation to attend scheduled appointments, as well as the challenges faced by the patient population in a safety-net hospital setting, such as limited resources and competing priorities. Additionally, the relatively high no-show rate in our clinic and the reliance on patients attending their scheduled visits posed challenges in maintaining consistent follow-up data, requiring coordination and rescheduling efforts by the study coordinator. The duration of follow-up was relatively short. Although we used questionnaires to evaluate multivitamin use, most patients were unable to report the name of the multivitamin or whether the multivitamin contained iodine. The dietary recall of iodine-rich foods helped us to understand participants' dietary iodine intake, but 24-hour recall may not reflect overall habitual iodine intake. Spot urinary iodine does not reflect individuals' chronic iodine intakes due to substantial day-to-day and even hour-to-hour variations (21).

Conclusions

In iodine-sufficient areas, bariatric surgery does not cause iodine deficiency or a significant change in thyroid function. Different surgical procedures with different anatomical alterations in the gastrointestinal tract do not significantly affect iodine absorption. After bariatric surgery, supplementation is required to prevent micronutrient deficiencies. Further studies to investigate the physiology of iodine absorption in patients following bariatric surgery are warranted.

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Highlights:

- Bariatric surgery does not result in iodine deficiency in patients in iodine-sufficient areas.
- Different bariatric procedures do not appear to cause differential iodine absorption from the small intestine.
- Intake of daily multivitamins and changes in dietary patterns after bariatric surgery may prevent iodine deficiency postoperatively.
- Changes in serum thyroid stimulating hormone (TSH) levels postoperatively correlated with the change in body mass index (BMI).

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Clinical Relevance:

Our results suggest that patients following bariatric surgery are not at risk of iodine deficiency if they continue a daily multivitamin and iodine-rich diet. Mild thyroid function changes postoperatively reflect the degree of weight loss.

Table 1.

Characteristics of the enrolled participants before and 3 months after surgery*

	Initial Visit (before surgery) (n=85)	3 months after surgery (n=62)
Age (year)	40.4 ±11.2	41.6 ±11.4
Sex (n, %)		
Male	12 (14.1)	9 (14.5)
Female	73 (85.9)	53 (85.5)
Race (n, %)		
Caucasian	30 (35.3)	22 (35.5)
African American	22 (25.9)	16 (25.8)
Hispanic	32 (37.7)	24 (38.7)
Others	1 (1.2)	0 (0)
Insurance type (n, %)		
Private	27 (31.8)	19 (30.7)
Medicare/Medicaid	58 (68.2)	43 (69.4)
Smoking status (n, %)		
Current	5 (5.9)	4 (6.5)
Former	23 (27.1)	19 (30.6)
Never	57 (67.1)	39 (62.9)
Alcohol history (n, %)		
Yes	20 (23.5)	15 (24.2)
No	65 (76.5)	47 (75.8)
BMI (mean ± SD)	44.0± 6.2	35.8 ±5.9
Obesity Classification based on BMI (n, %)		
Class I 25.0–29.9	0 (0)	8 (12.9)
Class II 30–39.9	22 (25.9)	44 (71.0)
Class III >=40	63 (74.1)	10 (16.1)
Surgical Procedure (n, %)		
Laparoscopic Roux-en-Y bypass	59 (69.4)	44 (71.0)
Laparoscopic sleeve gastrectomy	25 (29.4)	18 (29.0)
Apollo endosurgery overstitch	1 (1.2)	0 (0)

*Presented as mean ± SD or n (%)

BMI, body mass index

Table 2.

Urinary iodine concentration, serum TSH, and micronutrients levels at baseline and at 3 months after bariatric surgery*

Lab item (Reference range)	Initial visit (before surgery) [a]	3 months after surgery[a]	P value
Vitamin D (30 – 100 ng/mL)			
Deficient	77 (92.8)	27 (50.0)	**<0.001**
Sufficient	6 (7.2)	27 (50.0)	
Vitamin B12 (213 – 816 pg/mL)			
Deficient	1 (1.4)	1 (1.9)	0.826
Sufficient	71 (98.6)	52 (98.1)	
Ferritin (10 – 109 ng/mL)			
Deficient	1 (1)	3 (5.6)	0.136
Sufficient	83 (100)	51 (94.4)	
Folate (5.8 – 31.4 ng/mL)			
Deficient	1 (1.2)	1 (1.9)	0.730
Sufficient	83 (98.8)	51 (98.1)	
UIC (μg/L)	201.0 (120.0 – 288.5)[b]	334.5 (236.3 –740.3)[c]	**<0.001**
TSH (0.35 – 4.9 uIU/mL)	1.5 (1.2 – 2.0)[d]	1.1 (0.7 – 1.6)[e]	**<0.001**

*Presented as mean ± SD or median (25th, 75th percentile) or n (%)

a, n in each row represents number of laboratory values available at 3-month follow up

b, n=85 in the initial visit

c, n=52 at 3 months after surgery

d, n=84 in the initial visit

e, n=48 at 3 months after surgery

UIC, urinary iodine concentration; TSH, thyroid stimulating hormone

Table 3.

Dietary information in the past 24 hours at each evaluation

	Initial visit (before surgery) (n=85)	3 months after surgery (n=47)	P value
Bought table salt (n, %)	64 (75.3)	28 (59.6)	0.060
Salt added (n, %)	37 (43.5)	16 (34.0)	0.287
Seaweed (n, %)	0 (0)	1 (2.13)	0.177
Multivitamins (n, %)	30 (35.3)	43 (91.5)	**<0.001**
Multivitamins containing iodine (n, %)	30 (35.3)	42 (89.4)	**<0.001**
Dietary supplements (n, %)	30 (35.3)	37 (78.7)	**<0.001**
Dairy (n, %)	70 (82.4)	37 (78.7)	0.610
Soy milk (n, %)	2 (2.4)	2 (4.3)	0.542
Egg (n, %)	37 (43.5)	18 (38.3)	0.559
Bread (n, %)	48 (56.5)	18 (38.3)	0.046
Bagel (n, %)	11 (12.9)	3 (6.4)	0.241
Bread Roll (n, %)	11 (12.9)	7 (14.9)	0.754
Fish (n, %)	18 (21.2)	13 (27.1)	0.400
Shellfish (n, %)	15 (17.7)	5 (17.0)	0.350

Table 4.

Urinary iodine concentration and TSH level before and after surgery based on types of bariatric surgery[*]

	Laparoscopic Roux-en-Y bypass	Laparoscopic sleeve gastrectomy	P value
BMI before surgery	43.2 ± 4.9[a]	46.1 ± 8.0[b]	0.045
BMI 3 months after surgery	35.3 ± 5.9[c]	36.89 ±6.1[d]	0.358
UIC before surgery	211.0 (129.0 – 282.0)[a]	141.0 (111.5 – 323.0)[b]	0.457
UIC 3 months after surgery	328.0 (235.0 – 624.0)[e]	359.0 (236.0 – 896.0)[f]	0.640
TSH before surgery	1.6 (1.2 – 2.0)[a]	1.5 (1.1 – 1.9)[b]	0.891
TSH 3 months after surgery	1.1 (0.8 – 1.6)[g]	1.39 (0.7 – 1.8)[h]	0.634

[*]Presented as mean ± SD or median (25th, 75th percentile)

[a,]n=59 in the initial visit

[b,]n=25 in the initial visit

[c,]n=44 at 3 months after surgery

[d,]n=18 at 3 months after surgery

[e,]n=35 at 3 months after surgery

[f,]n=17 at 3 months after surgery

[g,]n=34 at 3 months after surgery

[h,]n=14 at 3 months after surgery

BMI, body mass index; UIC, urinary iodine concentration; TSH, thyroid stimulating hormone