Adherence to Micronutrient Supplementation in Bariatric Patients

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Abstract

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Background Micronutrient deficiencies are key concerns after bariatric surgery. Routine supplementation of certain vitamins and minerals is a lifelong requirement following bariatric procedures to minimize the risks of nutritional deficiencies on health. However, little is known about bariatric patient adherence to postoperative supplementation.

Objectives The aims of this study were to examine self-reported adherence to recommended micronutrient supplementation in bariatric patients, investigate their perceived barriers to achieving optimal adherence, and identify other factors that may affect patients' supplement purchase, choice and adherence.

Methods An online survey was developed and posted to two community support forums for Roux-en-Y gastric bypass surgery and vertical sleeve gastrectomy on the website BariatricPal.com. Data were collected between June 2, 2014 and September 24, 2014, including demographic information; supplement use, purchase, choice and adherence; experienced barriers to adherence; and patients' views about their functional health.

Results One hundred fifty four subjects who have undergone bariatric surgery responded to the survey. The micronutrients surveyed included multivitamin, thiamin, folic acid, iron, vitamin C, vitamin D, calcium, and vitamin B_{12}. Self-reported adherence rate to routine micronutrient supplementation ranged from 75% for calcium to 100% for folic acid. Missing doses and side effects associated with taking supplements were identified as the two leading barriers to adherence (42.4% and 21.2%, respectively). Approximately 92% of the study cohort purchased their OTC supplements in local stores or through internet. Bariatric branded supplements was considered by 24% of the respondents as the most important factor influencing their choice of supplements, followed by recommendations from care provider which was reported by 23% of the study sample.

Conclusion High self-reported adherence was observed in our study sample. However, the results showed that some respondents seemed not to be convinced by their care provider's instructions on postoperative nutritional care, and their barriers to supplement adherence were not adequately understood and addressed in follow-up care, which highlighted the need for providers to bridge the communication gap with bariatric patients and understand their perspectives and concerns regarding postoperative nutrient supplementation so as to optimize adherence to recommended micronutrient regimens.

Introduction

According to the 2013American Association of Clinical Endocrinologists / The Obesity Society /American Association of Metabolic and Bariatric Surgery Clinical Practice Guidelines, surgical approaches to treat obesity should be considered for individuals with a body mass index (BMI) $\geq$ 40 kg/m^2 without coexisting medical problems, and those with a BMI $\geq$ 35 kg/m^2 and one or more obesity-related comorbid conditions such as Type 2 diabetes, coronary artery disease and obstructive sleep apnea. Bariatric procedures may also be offered to patients with a BMI of 30-34 kg/m^2 with diabetes or metabolic syndrome[1].

Bariatric surgical procedures are classified as malabsorptive, restrictive, or a combination of the two. In 2011, 340,768 bariatric operations were performed worldwide by 6,705 bariatric surgeons, 101,645 of which were performed in USA and Canada by 1,248 surgeons[2]. The most commonly performed procedures were Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG), and adjustable gastric band (AGB)[2]. The RYGB, considered the gold standard technique, combines both restrictive and mild malabsorptive mechanisms by creating a small gastric pouch of 15-20 mL in size and excluding the distal part of the stomach, duodenum, and proximal jejunum[3]. Significant weight loss achieved after RYGB can be explained by reduced food intake and absorption, as well as changes in gastrointestinal hormone production that influence regulation of appetite and satiety[3,4]. However, this procedure may entail a high risk of micronutrient deficiencies[5]. The SG involving only the stomach creates a small sleeve by surgically stapling and resecting the stomach at the larger curvature to decrease the capacity of the stomach, which is generally considered as a restrictive procedure. One of the advantages of the SG, based on relatively limited long-term

data, is that it appears to result in fewer micronutrient deficiencies and associated complications than those typically observed after malabsorptive procedures[6,7]. The AGB works by placing a donut-shaped balloon, which is inflatable by saline, around the upper portion of the stomach, creating a small upper gastric pouch that is similar in size to the gastric pouch created in RYGB, and an unobstructed lower stomach. The size of the upped gastric pouch causes a restrictive effect and limits food intake. As a purely restrictive procedure, the risks of severe nutrient deficiencies were thought to be lower that RYGB and SG because the anatomy of the gastrointestinal tract is left intact[4,8].

The most common micronutrient deficiencies after bariatric surgery are vitamin B_{12}, iron, folate, calcium, vitamin D and thiamin[5-10]. These deficiencies may arise from reduced quantity and quality food intake, food intolerance, and altered digestion and absorption due to changes in the gastrointestinal anatomy and physiology[9, 27]. A retrospective study of self-reported intake among 69 RYGB patients over a postoperative period of 18 months to 4 years showed that calcium and folic acid intake were only 68% and 61% of Recommended Dietary Allowance (RDA)[28]. Iron and vitamin B_{12} intakes have also been reported below recommended levels due to reduced protein intake[29, 30]. In another prospective study of 113 RYGB patients, foods not well tolerated after surgery included milk (25%), steak (16%), minced beef (12%), and bread (8%)[31], all of which could contribute to reduced dietary intake of iron, B_{12} and calcium.

Furthermore, restricting stomach size and bypassing the duodenum and proximal jejunum result in decreased secretion of gastric acid, pepsin and intrinsic factor, as well as reduced overall contact time and mixing between digestive enzymes with food. This may

contribute to mild nutrients malabsorption. Over time, micronutrient deficiencies can occur[27]. The absence of adequate postoperative supplementation of micronutrients will likely further increase the risk of nutrient deficiencies.

Therefore, routine supplementation of vitamins and minerals is a lifelong requirement for all bariatric surgery patients to minimize the risks of nutritional deficiencies on health[1]. The importance of postoperative nutritional supplementation has been widely recognized by researchers and clinicians. Clinical practice guidelines have also been established for postoperative care of bariatric patients that include routine nutrition screening and mandatory recommendation of appropriate supplements to patients with, or at risk for, micronutrient insufficiencies or deficiencies[1]. However, recent studies continue to show that it is not uncommon to develop nutrient deficiencies after receiving bariatric surgical preocedures[10,11,26], yet few studies have gained insight into patients' perspectives on micronutrient regimens after bariatric surgery, such as their use of supplements, motivational factors, barriers, concerns and adherence, which provide a complete picture of treatment impact. Modi et al. studied short-term self-reported adherence to multivitamin in 41 adolescent patients who underwent gastric bypass and sleeve gastrectomy. A mean adherence rate of 78.6% was documented in the week prior to the 6-month postoperative clinic visit. The research by Modi also examined barriers to multivitamin therapy for the adolescent bariatric population; forgetting and difficulty swallowing pills were identified as the primary barriers to adherence in adolescents[12]. However, no prior studies have investigated adherence and barriers to micronutrient supplementation among adult patients, and it is unknown if the barriers identified by adolescents who have undergone bariatric surgery will apply in adults.

Furthermore, little is known about adherence to different types of micronutrient supplement regimens in the bariatric populations. Finally, factors influencing bariatric patients' choice of nutritional supplements can be relevant to supplementation adherence after surgery, and this potential impact has received little research attention.

The aims of this study were to: 1) examine self-reported adherence to recommended micronutrient supplementation in patients who had bariatric surgery, and 2) investigate bariatric patients' perceived barriers to supplement adherence. An exploratory aim was to identify other factors that may affect bariatric patients' supplement purchase, choice and adherence. This information was obtained using an online survey. The hypothesis was that self-reported adherence would be low at < 50% and that forgetting to take the supplements would be the major barrier to adherence endorsed by the bariatric patients.

Understanding the reasons for non-adherence would enable care providers to tailor education and interventions to address distinctive adherence barriers and concerns in individuals who have undergone RYGB or SG surgery, thereby improving adherence to nutritional supplementation and ultimately postoperative long-term health outcomes.

Methods

Study Design and Population

An online survey was developed to assess patient self-reported adherence to micronutrient supplementation and barriers to compliance after their bariatric surgery. The survey was administered via SurveyMonkey.com (LLC, Palo Alto, California), an online survey and quiz tool. The survey questionnaire consists of three parts: 1) subject demographic

information and general questions about the bariatric surgery they had; 2) adherence and barriers to the use of micronutrient supplements and questions regarding supplement purchase and choice; and 3) SF-12® Health Survey measuring respondents' views about their functional health and well-being. Upon agreeing to participate in the study and entering the online survey, respondents first completed their background information and then were directed to the second part, followed by the short form health survey. The survey was posted to two online community support forums for Roux-en-Y gastric bypass surgery and vertical sleeve gastrectomy, both of which belong to BariatricPal.com, a weight loss surgery social network in the U.S. Approval of the director of BariatricPal.com was obtained before the survey was published on the website, and the research has been certified as exempt from review by the University of Washington Institutional Review Board. Data were collected between June 2, 2014 and September 24, 2014.

Measures

Medical and sociodemographic information. Respondents were asked demographic questions including their sex, age, race, employment status, family income, and health insurance status. Height and current weight was collected to calculate the BMI of respondents. Questions on surgery type and when they had the surgery were also included.

Self-reported adherence. Several questions were asked regarding recommended micronutrient supplementation by their bariatric team, including type and quantity. Respondents were then asked about their actual use of micronutrient supplements in terms of type and dose. Respondents were considered adherent to a supplement regimen if they were taking the

supplement exactly as they were instructed or more than the prescribed dose. Respondents were considered non-adherent if their current intake was less than recommendation as determined by their provider or not consistently. Adherence rate was defined as the percentage of adherent respondents out of the total number of respondents who were advised to take a micronutrient and able to report both the recommended dose and their current intake of the supplement. For respondent who were unable to recall what their provider's recommendations of micronutrient supplement schedule were, their responses were not included in the calculation of overall adherence rate.

Barriers to adherence. Potential barriers were listed for respondents to select, including forgetting, affordability, side effects, difficulty in finding the recommended supplements, and confusion about care provider's instructions, and they were asked to select one major cause of their difficulty in achieving optimal adherence. Respondents were also encouraged to report barriers they experienced that may not be on the list.

Supplements purchase and choice. A couple of questions were about where respondents usually purchase their supplements and what factor mainly influences their choice of supplements at purchase time, including cost, availability, bariatric branded supplements, and specific product recommendations by care provider or support groups. Respondents were able to reply with their own answer if it was not included in the provided list of options.

Health Status. The 12 questions from the 12-item Short Form (SF-12®) Health Survey were used to measure respondents' physical and mental functioning during the past 4 weeks from their point of view. Physical Component Summary (PCS) measure and Mental Component

Summary (MCS) measure scored from the SF-12 survey provided an overview of a respondent's health status from both a physical and a mental health perspective.

Statistical Analyses

Descriptive statistics were used for qualitative and quantitative survey results: percentage, median, mean, and standard deviations. The AGB, RYGB and SG groups were compared on general characteristics by using one-way ANOVA and χ^2 test for parametric and categorical data, respectively. The SF-12 PCS and MCS measures were computed and standardized to a mean of 50 and a standard deviation of 10 by the QualityMetric Health Outcomes™ Scoring Software 4.5 in relation to 2009 U.S. general population norms; that is, scores obtained above and below 50 could be interpreted as being above and below the average, respectively, in the 2009 U.S general population[13]. A value of $p < 0.05$ was considered statistically significant. Statistical analyses were conducted using Stata (version 11, 2009, StatCorp LP).

Results

Subject Characteristics

Between June 2 and September 24, 2014, a total of 161 subjects accessed the link to the survey. One hundred fifty eight subjects accepted the consent to proceed with the survey whereas three declined participation. Additionally, four respondents who had initially accepted the consent did not respond to the survey questions at all. Consequently, a study sample of 154 respondents was included for analysis. Among these respondents, 95 (61.7%) underwent SG; 52 (33.8%) received RYGB; 3 (1.9%) had AGB; and 4 did not specify the type of the surgery they had. Almost 90% of the SG respondents and 81% of the RYGB

respondents received their surgery within the past 12 months, whereas all the AGB respondents received their surgery over ten years ago.

Respondents' characteristics are shown in Table 1. The majority of respondents was female (90%) and Caucasian (83%), aged 30 to 59 years (86%), and presented a mean current BMI of 35.3 ± 7.3 kg/m^2 postoperatively. They were predominantly employed at the time of the survey (73%) and had private health insurance (80%). The median range of annual household income of the cohort was $75,000 to $99,999. The average SF-12 PCS score was 51.1 ± 10.2, and the average MCS score was 52.3 ± 7.9. There were no significant differences between surgery groups in characteristics of respondents, except for race (P = .006) and postoperative period (P < .001).We acknowledge that the sample size of the AGB group was extremely small (n=3), which limits the interpretation of its results.

Postoperative micronutrient supplementation and adherence

Eighty-eight percent of the survey respondents, including the majority of the RYGB (89%) and SG (90%) respondents, affirmed that they had been advised to take certain vitamins and minerals by their bariatric team after surgery. Of these, nearly all (> 95%) indicated that they remember the specific micronutrient regimens as recommended by their care provider (Table 1). Only one AGB respondent reported being asked to start a micronutrient regimen that included multivitamin without iron, thiamin, folic acid and vitamin D.

Multivitamin and mineral. Of all respondents, 63% were recommended to take multivitamin and mineral with iron, while 26% were suggested to take multivitamin and mineral without

iron (Table 2a). Among these, four respondents reported that both kinds of multivitamin were recommended; however, it was unclear if they were told to take either one or both at the same time. As shown in Table 2b, 53% of the respondents are currently taking multivitamin with iron and 20% taking the one without iron, either as instructed or voluntarily. Self-reported adherence rate was 87% for multivitamin with iron and 89% for multivitamin without iron (Table 3).

Thiamin. Much lower percentage of respondents (16%) received specific recommendation for additional, stand-alone thiamin supplementation (Table 2a).Twelve percent of the total sample reported that they are currently taking thiamin, of which two specified that thiamin was included in their multivitamin (Table 2b). Self-reported adherence rate for thiamin was 86% (Table 3).

Folic acid. Only 10% of the respondents reported having been specifically recommended to take an additional, stand-alone folic acid supplement (Table 2a). Nine percent of the entire cohort reported current intake of folic acid, of which three respondents include folic acid in their multivitamin (Table 2b). Self-reported adherence rate was 100% (Table 3).

Iron. Fifty-nine (38%) respondents reported being advised to take iron supplement postoperatively (Table 2a). Forty-four (29% of the total sample) were actually supplementing it, of which three respondents have iron in their multivitamin and one specified taking Vitron C, an iron and vitamin C combination (Table 2b). Iron self-reported adherence rate was 83% (Table 3).

Vitamin C. Similar to thiamin and folic acid, few respondents (n=24, 16%) reported being

provided with recommendations on vitamin C regimen (Table 2a). Of the 18 respondents (12% of the cohort) taking vitamin C, two include it in the multivitamin and one has it with iron (Table 2b). Median daily vitamin C intake is 500 mg (n=6) in RYGB group and 1000 mg (n=6) in SG group. Mean intake of vitamin C is considerably greater (4000 mg/day) in SG group because one respondent is taking 10,000 mg twice a day (Table 2c). Self-reported adherence rate for vitamin C was 93% (Table 3).

Calcium. Of the entire sample, 79% had recommended calcium regimen from their bariatric team (Table 2a); 60% reported current calcium supplement intake, of which four are taking it with vitamin D or with multivitamin (Table 2b). Mean and median daily intake of calcium is approximately 1200 mg and 1000 mg, respectively, in both RYGB and SG groups (Table 2c). Compared to other micronutrient supplements, respondents reported the lowest adherence to calcium (~75%) across the board, as shown in Table 3.

Vitamin D. Of all respondents, 53% reported being told to take vitamin D supplement (Table 2a); 45% affirmed current use of vitamin D, of which four respondents are taking it with calcium and one includes it in multivitamin (Table 2b). Mean and median daily vitamin D intake is about 2400 IU and 2000 IU, respectively, in RYGB group, and about 3300 IU and 3000 IU, respectively, in SG group (Table 2c). Vitamin D self-reported adherence rate was 97% (Table 3).

Vitamin B_{12}. Of the entire study cohort, 69% reported that a post-operative B_{12} regimen was recommended (Table 2a); 52% are supplementing B_{12} in oral, sublingual, intranasal or intravenous form, of which two respondents include it in their multivitamin (Table 2b). Both

RYGB and SG groups demonstrated a median daily B_{12} intake of 750 mcg, and the average dose of B_{12} injection administered was 1500 mcg/month (Table 2c). Self-reported adherence rate for B_{12} was 96% (Table 3).

Barriers to adherence

Table 4 summarizes reported barriers to micronutrient supplementation experienced by the respondents who had undergone bariatric surgery. Of the 137 subjects who responded to these questions, Less than half (48.2%) felt that it had been difficult to take the recommended vitamins and minerals. Forgetting, side effects, and unpleasant taste and flavor were the top three barriers identified by the respondents. Besides the barriers listed in the table, one respondent admitted that she just disliked any supplements, and one reported confliction between micronutrient and other medication regimens.

Supplement purchase and choice

One hundred thirty six subjects responded to the question "where do you usually purchase your vitamin and mineral supplements?" Over half of them (53.7%) reported purchasing over-the-counter micronutrient supplements in local pharmacy, drugstore, nutritional supplement store, or convenience store. Purchasing supplements through the internet was shown to be the second most popular approach among the respondents (Table 5).

One hundred thirty seven subjects responded to the question "what is the most important factor that influenced your choice of supplement?" As shown in Table 5, the highest percentage of respondents (24.1%) identified "bariatric branded supplements" as the major factor they considered, followed by "recommended by care provider" (22.6%) and costs

(20.4%). Besides the factors listed in the table, one respondent reported making choice based on previous usage, and one considered potential side effects associated with supplements.

Discussion

The study subject demographics were comparable to recent research based on the University HealthSystem Consortium (UHC) Clinical Database, reporting that patients undergoing bariatric surgeries between October 2011 and September 2012 were largely female (76%-79%), Caucasian (61%-71%), and aged 31 to 65 years (76%-85%)[14]. In addition, the distribution of bariatric surgeries in the sample reflected the recent trend in the percentage of bariatric procedures in the U.S. From October 2008 to September 2012 at the national level, there was a dramatic decrease in laparoscopic AGB from 23.8% to 4.1%, a marked increase in laparoscopic SG from 0.9% to 36.3%, and a concurrent decline in laparoscopic RYGB from 66.8% to 56.4% [14]. While SG is becoming more and more popular because of its safety and effectiveness in weight loss, AGB has dropped off in popularity due to high reoperation rates, long-term complications, band erosion and poor weight loss.

Adherence

Overall, the results of this study demonstrated high self-reported adherence (≥ 75%) to various types of micronutrient supplementation in respondents who have undergone bariatric surgeries, which contradicted the hypothesis that adherence would be low (< 50%). When compared among supplement types, the lowest adherence rates were observed for calcium and iron. Our results are similar to those of Modi et al. that found high mean self-reported adherence rates of 88.4% and 78.6% to multivitamins in the adolescent bariatric patients at

the 1-month and 6-month assessment, respectively[12]. Their results also demonstrated declining adherence over the first 6 postoperative months[12]. Therefore, it is important to acknowledge that the high adherence rates observed in this study may be associated with the fact that the majority of the respondents had their surgery within the last 12 months, and whether adherence tends to decline over time was not able to be examined by the current study design.

Calcium supplements typically contain calcium carbonate or calcium citrate. Most respondents reported using the citrated form of calcium, which is much more expensive than the carbonated form. This may be because some marketers claim that calcium citrate absorbs better than carbonate, and citrate is usually recommended as the first-line replacement supplement by care providers and guidelines[1]. However, early studies by Heaney et al. found that the two forms of calcium absorbed almost equally well when taken with food, and solubility and stomach acidity had little or no effect on absorption of any calcium salts[19, 20]. Calcium supplementation adherence has rarely been studied in bariatric population, and thus relevant knowledge is very limited. In the current study, several respondents reported having difficulty with taking calcium supplements because of huge dosage (e.g. 4 calcium citrate chewables a day), swallowing difficulty, and separate times of calcium and other supplements administration for maximum absorption, which may help explain the relatively poor self-reported adherence to calcium regimens in the study subjects.

Iron recommendations often include ferrous salts (ferrous sulfate, fumarate and gluconate). Side effects of oral iron therapy, such as nausea, constipation and dyspepsia, are common that may result in low patient adherence rates. Research on iron supplementation

tolerability and adherence has been primarily conducted in pregnant or postpartum women, in which non-adherence rates for iron have been found as high as 30% to 40% due to the side effects[32, 33]. However, tolerability and adherence studies related to iron supplementation in bariatric patients have been sparse[18], and therefore it was unclear whether the low adherence to iron observed in the current study was related to iron-induced constipation and unpleasant gastrointestinal complications. Ferrous sulfate is commonly used as the oral iron preparation given its good bioavailability, efficacy, low cost, and availability without a prescription[1, 16, 17]. In addition, a systemic review by Manasanch et al. found that sustained-release ferrous sulfate preparations have lower incidence of gastrointestinal side effects and are better tolerated than any other preparations[34]. A dose-dependent effect of iron on the digestive tract has been described by Ekstrom et al. in which administered doses of 50 mg vs. 120 mg of elemental iron were with 12% and 20% of side effects, respectively[35]. A recent study by Souza et al. also demonstrated a growing trend in the side effects as the dosage of ferrous sulfate increased (60 mg once weekly vs. twice weekly vs. daily)[32]. Thus, recommendation of appropriate iron formulations and avoidance of unnecessary high doses of iron should be considered when recommending iron supplementation to bariatric patients to reduce potential gastrointestinal complications.

Monthly out-of-pocket costs of taking oral iron supplements and calcium citrate can be over $10 in total, especially when high dose is prescribed for diagnosed nutrient deficiencies. Along with other required nutrients, roughly $20 would be spent monthly on supplements. For bariatric branded supplements, one monthly supply usually costs around $20 to $30. However, additional doses or individual nutrients may need to be added to meet the minimal

nutritional requirements[1], for example, addition of calcium to Bariatric Advantage® and additional doses of vitamin D and B_{12} to Bariatric Fusion®. Anyhow long-term postoperative micronutrient regimens can impose a substantial financial burden on those undergoing bariatric surgery, notably low-income patients, making adherence difficult. Furthermore, patients are less likely to adhere to nutritional supplementation if they do not think it is important or effective.

One respondent explained her non-adherence to multivitamin with iron by high blood iron level per lab results, and one respondent did not follow her calcium regimen due to high blood calcium level. Routine nutritional screening after bariatric surgery is equally as important as supplementation[1]. It helps determine if nutrient deficiencies or excesses exist so that appropriate adjustment to supplement regimens can be made in time. Some respondents reported taking much larger dose of certain micronutrients (e.g. 50,000 IU/weekly vitamin D) than others, probably for replacement therapy.

Folate, iron, vitamin B_{12}, calcium and vitamin D deficiencies have been frequently observed and described after bariatric surgery, with widely varying prevalence[5-11]. For postoperative patients, the current clinical practice guidelines recommend minimal daily nutritional supplementation that includes 1-2 adult multivitamin and mineral (including iron, folic acid and thiamin), 1200-1500 mg of elemental calcium, and at least 3000 IU of vitamin D[1]. Total elemental iron provided daily should be at least 45-60 mg via multivitamins and additional supplements[1]. For patients with SG and RYGB that exclude the lower part of the stomach, the guidelines recommend oral vitamin B_{12} at least 1000 mcg daily or parental B_{12} supplementation at 1000 mcg monthly to 1000-3000 mcg every 6 to 12 months[1]. Our study

demonstrated that multivitamin and mineral with iron, calcium, vitamin D and vitamin B_{12} were the most commonly recommended supplements to the bariatric patients by their providers, whereas specific instructions on thiamin, folic acid, iron and vitamin C supplementation were much less often provided (Table 2a), because these micronutrients were usually recommended and included in routine multivitamin and mineral preparation without paying attention to individual nutrient dose. Moreover, results from the study showed that recommendations on micronutrient supplementation provided to bariatric patients by care providers varied greatly, and more than half of the study subjects did not achieve the calcium, vitamin D and vitamin B_{12} regimens recommended by the guidelines (Table 2c). However, we noted that the guidelines are being revised, and an updated version will be released in several months. It would be interesting to compare the results to the new guidelines when they are available.

Barriers

The leading barriers to micronutrient supplementation identified by the respondents were forgetting and side effects (Table 4). In the survey, some respondents reported feeling nauseous when taking supplements and several attributed it to being lately out of surgery (2-4 weeks post-op) and the limited size of the stomach. Three respondents reported having timing issues with supplementation, because they were told to take different supplements at different times with or without food /drink (e.g. meal, water, juice), which made them feel difficult to fit all regimens into their schedule.

Other factors affecting adherence

The majority of the respondents purchased their supplements as OTC products in local stores or pharmacy or through internet; however, the question is whether the patients are equipped with adequate knowledge to take control over their self-care selections and how care providers can empower them to make appropriate choice. Among the respondents who purchased supplements from their physicians, one explained that she had to purchase them from the surgeon because the OTC supplements recommended by her surgeon were hard to find. This suggests that care providers should recommend products readily available to their patients; otherwise they may find inappropriate substitutes or simply give up trying.

Factors identified by bariatric patients that influence their choice of supplement can be used to explore underlying reasons for non-adherence and as clues towards better patient education and adherence improvement. Unexpectedly, bariatric branded supplement was recognized by the study subjects as the primary factor to consider when choosing a supplement, slightly more important than care provider's recommendations (Table 5). This finding seems to suggest that those supplement companies have successful marketing techniques to promote their bariatric products so that customers are more convinced by the "bariatric brand" than their care providers. In addition, one respondent specifically commented that although she understood her provider's instructions on the importance of taking nutritional supplements after surgery, she has discounted the recommendations until she actually witnessed the awful outcomes of not getting the right amount of nutrients in other bariatric patients, which then convinced her to make it priority to taking them to maintain her health. This draws attention to a communication gap between bariatric patients

and their care providers, highlighting the importance for providers to get fully prepared to support their patients with adequate education and follow-up to ensure proper selection of nutritional supplement products. Not surprisingly, cost was not recognized as the primary barrier to adherence or the major factor in choosing supplements, because this study population has a good employment rate, few of them receiving Medicare and most having moderate annual household income.

Implications

Deficiencies of iron, vitamin B_{12}, folate, calcium, vitamin D and thiamin can result in clinically significant anemia, osteopenia and neurological disorders in some patients[21-24]. Lifelong vitamin and mineral supplementation is considered the standard of care in bariatric practice[1], and adherence to micronutrient regimens after bariatric procedure is essential for effective prevention of postoperative nutritional deficiencies.

This study offers unique insight into bariatric patients' perspectives on postoperative nutritional care and has several implications for clinical practice. Previous studies showed that the recommended supplementation may not be enough to suppress nutritional needs or prevent micronutrients deficiencies in the postoperative period[25, 26]; however, few studies have examined patient adherence to supplementation concurrently. This highlights the need for means to monitor and keep track of patient adherence in order to make meaningful decisions about clinical care. For example, if a patient has continued micronutrient deficiency because of poor compliance with recommended supplementation, but the physician increases the dose or changes the supplement without considering the patient's adherence, the true problem is not targeted and would not be solved. The identification of adherence barriers and

factors in choosing supplements could increase care providers' awareness of their patients' concerns and issues regarding supplement intake and instructions. Therefore, if a patient's non-adherence is suspected and underlying barriers are recognized, pertinent treatment and education could be applied to the patient focused on problem-solving. Furthermore, it is likely that there was a lack of adequate and effective communication between patients and providers, which should be called attention to.

Limitations

There are several limitations to this study. First, all the data were collected from the respondent's self-report by the use of the survey, which was subject to recall and self-report biases. Second, the study subjects were recruited in the online community support groups for individuals undergoing bariatric surgeries, and thus the pool of respondents is limited to those who have the ability to use the internet and those being inherently motivated to manage their own health, as reflected by the SF-12 results that the study sample had better self-assessed mental and physical health than the general US population, which limits the generalizability of the findings to similar bariatric population. Nonetheless, online survey has its strengths, one of which was that the respondents might be less likely to give more desirable answers they felt the providers wanted to hear. Third, since the majority of the respondents had their surgery over the past year, the long-term adherence to micronutrient supplementation remains unknown. Finally, with varied number of missing responses on questions, results were limited to available data.

Conclusion

In our study population, high self-reported adherence to different micronutrient supplementations was observed. Missing dose and side effects associated with taking supplements were identified as the two leading barriers to optimal adherence. About 92% of the respondents purchased OTC supplements in local stores or through internet. The greatest percentage of the respondents considered bariatric branded supplements as the most important factor that influenced their choice of supplements, and recommendations from care provider were rated as the second important factor. To our knowledge, few studies have addressed supplementation adherence issues in bariatric population, and there is a critical need to further fill this gap in the literature. Future studies should include bariatric patients with low socioeconomic status or comorbidities, who are likely at high risk of non-adherence to postoperative micronutrient regimens, and examine their long-term adherence after surgery.

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Table 1. Subject Characteristics

Characteristic	Total (n=154)[a]	AGB (n=3)	RYGB (n=52)	SG (n=95)	P value[f]
Age, y, n (%)					0.08
21-29	8 (5.3)		2 (3.8)	6 (6.3)	
30-39	37 (24.5)		13 (25.0)	24 (25.3)	
40-49	56 (37.1)	1 (33.3)	19 (36.5)	35 (36.8)	
50-59	37 (24.5)		14 (26.9)	23 (24.2)	
≥60	13 (8.6)	2 (66.7)	4 (7.7)	7 (7.4)	
Sex, n (%)					0.34
Female	138 (90.2)	2 (66.7)	48 (92.3)	85 (89.5)	
Male	15 (9.8)	1 (33.3)	4 (7.7)	10 (10.5)	
Current BMI, kg/m2, mean + SD	35.3 (7.3)[b]	34.8 (5.5)	35.1 (7.3)[b]	35.5 (7.4)	0.94
Race, n (%)[c]					
Caucasian	125 (83.3)	2 (66.7)	39 (76.5)	82 (87.2)	0.006
Latino/Hispanic	12 (8.0)		5 (9.8)	6 (6.4)	
African-American	9 (6.0)		4 (7.8)	5 (5.3)	
Asian/Pacific islander	3 (2.0)		2 (3.9)	1 (1.1)	
Native American/American Indian	2 (1.3)		1 (2.0)	1 (1.1)	
Other	2 (1.3)	1 (33.3)	0	1 (1.1)	
Prefer not to respond	3 (2.0)		1 (2.0)	2 (2.1)	
Employment, n (%)					0.69
Unemployed	24 (16.0)		7 (13.7)	17 (20.0)	
Employed	109 (72.7)	2 (66.7)	38 (74.5)	68 (71.6)	
Retired	17 (11.3)	1 (33.3)	6 (11.8)	10 (10.5)	
Household Annual Income, n (%)					0.91
Less than $20,000	10 (6.6)		4 (7.7)	5 (5.3)	
$20,000 to $34,999	14 (9.3)		6 (11.5)	8 (8.5)	
$35,000 to $49,999	11 (7.3)		5 (9.6)	6 (6.4)	
$50,000 to $74,999	32 (21.2)	1 (33.3)	7 (15.4)	23 (24.5)	
$75,000 to $99,999	34 (22.5)	1 (33.3)	10 (19.2)	23 24.5)	
$100,000 to $149,999	32 (21.2)	1 (33.3)	12 (23.1)	20 (21.3)	
$150,000 or more	18 (11.9)		8 (15.4)	9 (9.6)	
Health Insurance, n (%)					0.5
Medicare	13 (8.6)	1 (33.3)	4 (7.7)	8 (8.5)	
Medicaid	3 (2.0)		2 (3.8)	1 (1.1)	
Other government insurance	10 (6.6)		6 (11.5)	4 (4.3)	
Private insurance	121 (79.6)	2 (66.7)	38 (73.1)	79 (84.0)	
None/Private pay	5 (3.3)		2 (3.8)	2 (2.1)	
When had the bariatric surgery, n (%)					<0.001
In the past year	128 (84.2)		41 (80.8)	85 (89.5)	

1 to 2 years ago	11 (7.2)		7 (13.5)	4 (4.2)	
3 to 5 years ago	6 (3.9)		1 (1.9)	5 (5.3)	
6 to 10 years ago	4 (2.6)		3 (5.8)	1 (1.0)	
More than 10 years ago	3 (2.0)	3 (100)	0	0	
Bariatric team recommended vitamin and mineral supplementation, N (%)[d]	135 (87.7)	1 (33.3)	46 (88.5)	85 (89.5)	0.01
Respondent knows the recommendation, n (%)					0.97
Yes	129 (95.5)	1 (100)	44 (95.7)	81 (95.3)	
No	6 (4.5)		2 (4.3)	4 (4.7)	
SF-12 Health Score, mean + SD[e]					
Physical component score	51.1 (10.2)	44.0 (19.1)	50.1 (11.5)	51.8 (9.3)	0.33
Mental component score	52.3 (7.9)	47.9 (3.9)	53.3 (8.0)	52.0 (8.1)	0.43

Abbreviations: AGB, adjustable gastric banding; BMI, body mass index; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy.

Sample sizes for characteristics vary due to missing responses and reflect numbers of respondents with available data.

[a] 4 respondents did not specify the type of surgery they had.

[b] One missing response in the RYGB group: total n=153; AGB n=3; RYGB n=51; SG n=95.

[c] Available responses: total n=150; AGB n=3; RYGB n=51; SG n=94. 6 respondents selected two race categories and were counted twice.

[d] Percentage (%) calculated as N divided by the total number of respondents of each surgery type.

[e] Available responses: total n=135; AGB n=3; RYGB n=45; SG n=83.

[f] *P* values compare the three surgery groups and were obtained by one-way ANOVA for parametric variables and Chi square test for categorical variables.

Table 2a. Percentage of respondents advised to take a specific micronutrient supplement.

Supplement type	Total (n=154)[a]	AGB (n=3)	RYGB (n=52)	SG (n=95)
Multivitamin and mineral with Iron, n (%)	97 (63.0)		33 (63.5)	61 (64.2)
Multivitamin and mineral without iron, n (%)	40 (26.0)	1 (33.3)	15 (28.8)	24 (25.3)
Thiamin, n (%)	24 (15.6)	1 (33.3)	7 (13.5)	15 (15.8)
Folic acid, n (%)	16 (10.4)	1 (33.3)	6 (11.5)	9 (9.5)
Iron, n (%)	59 (38.3)		25 (48.1)	32 (33.7)
Vitamin C, n (%)	24 (15.6)		9 (17.3)	15 (15.8)
Calcium, n (%)	121 (78.6)		44 (84.6)	75 (78.9)
Vitamin D, n (%)	82 (53.2)	1 (33.3)	33 (63.5)	46 (48.4)
Vitamin B12, n (%)	106 (68.8)		38 (73.1)	66 (69.5)

Abbreviations: AGB, adjustable gastric banding; NA, not available; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy.

Sample sizes reflect numbers of respondents with available data.

Table 2b. Percentage of respondents currently taking the supplement[b].

Supplement type	Total (n=154)[a]	AGB (n=3)	RYGB (n=52)	SG (n=95)
Multivitamin and mineral with Iron, n (%)	82 (53.2)	1 (33.3)	30 (57.7)	49 (51.6)
Multivitamin and mineral without iron, n (%)	31 (20.1)	0	16 (30.8)	15 (15.8)
Thiamin, n (%)	18 (11.7)	1 (33.3)	5 (9.6)	11 (11.6)
Folic acid, n (%)	14 (9.1)	1 (33.3)	4 (7.7)	9 (9.5)
Iron, n (%)	44 (28.6)	1 (33.3)	19 (36.5)	22 (23.2)
Vitamin C, n (%)	18 (11.7)	0	7 (13.5)	11 (11.6)
Calcium, n (%)	92 (59.7)	1 (33.3)	36 (69.2)	53 (55.8)
Vitamin D, n (%)	69 (44.8)	2 (66.6)	26 (50.0)	40 (42.1)
Vitamin B12, n (%)	79 (51.5)	1 (33.3)	28 (53.8)	48 (50.5)

Abbreviations: AGB, adjustable gastric banding; NA, not available; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy.

Sample sizes reflect numbers of respondents with available data.

[a] 4 respondents did not specify the surgery type they had.

[b] Includes respondents taking supplements with recommendations and those taking voluntarily without recommendations.

Table 2c. Average and median dose of the supplements taken by the respondents

Supplement type[a]	Total			AGB		RYGB			SG		
	n	mean	median	n	mean	n	mean	median	n	mean	median
Vitamin C, mg/d	12	2325[b]	750			6	650	500	6	4000[b]	1000
Calcium, mg/d	64	1192	1000	1	1000	28	1203	1000	35	1182	1000
Vitamin D, IU/d	53	2943[c+d]	2000	2	5000	20	2427[c]	2000	31	3276[d]	3000
Vitamin B12											
mcg/d	71	851[e]	750	1	500	26	747	750	44	913[e]	750
mcg shot/month	2	1500							2	1500	

Abbreviations: AGB, adjustable gastric banding; NA, not available; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy.

Sample sizes reflect numbers of respondents with available data.

[a] Excludes supplements with dose reported as pills in the survey.

[b] 1 respondent is taking 200% RDA for vitamin C = 75 mg/day x 2 for adult female; one is taking 10,000 mg twice a day, as an outlier.

[c] 1 respondent is taking 50 IU/day vitamin D, one is taking 10,000 IU/day.

[d] 3 respondents are taking 50,000 IU/week vitamin D, one is taking 10,000 IU/day.

[e] Includes oral and nasal spray, Nascobal® nasal spray, 1 spray = 500 mcg vitamin B12. 2 respondents are taking 5,000 mcg/day.

Table 3. Self-reported adherence rate to micronutrient supplementation

	Total	**AGB**	**RYGB**	**SG**
Supplement Type	Adherence rate, % (n/*N*) [a]	Adherence rate, % (n/*N*) [a]	Adherence rate, % (n/*N*) [a]	Adherence rate, % (n/*N*) [a]
Multivitamin and mineral with Iron	86.7 (72/83)		87.1 (27/31)[i]	86.0 (43/50)
Multivitamin and mineral without iron	88.9 (24/27)		100 (14/14)	76.9 (10/13)
Thiamin	85.7 (12/14)[b]		100 (5/5)	75.0 (6/8)
Folic acid	100 (8/8)[c]		100 (4/4)	100 (4/4)
Iron	82.5 (33/40)[d]		94.7 (18/19)	68.4 (13/19)
Vitamin C	93.3 (14/15)[e]		100 (7/7)	87.5 (7/8)
Calcium	75.0 (60/80)[f]		77.4 (24/31)	75.0 (36/48)[i]
Vitamin D	96.6 (56/58)[g]	100 (1/1)	91.7 (22/24)	100 (32/32)
Vitamin B12	95.7 (66/69)[h]		92.6 (25/27)	90.5 (38/42)

Abbreviations: AGB, adjustable gastric banding; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy.

[a] *N* is the total number of respondents who were advised to take a micronutrient supplement and able to report both the recommendation and their actual consumption of the supplement. n is the number of respondents adherent to their supplement recommendation, defined as those who are taking the supplement exactly the as they were instructed or more than the recommended dose. Adherence rate defined as (n/N) x 100%.

[b] 3 respondents were not captured: 2 include thiamine in multivitamin; 1 takes IV thiamin instead of pills as recommended.

[c] 5 respondents were not captured: 3 include folate in multivitamin; 1 takes IV folic acid instead of pills as recommended; 1 takes pill instead of liquid form of folic acid as recommended.

[d] 5 respondents were not captured: 4 include iron in multivitamin or with vitamin C; 1 reported different units (pill vs. mg)

[e] 2 respondents were excluded as they include vitamin C in multivitamin.

[f] 8 respondents were not captured: 3 include calcium in multivitamin or with vitamin D; 4 reported different units (pill vs. mg); 1 uses time-release version instead of pills as recommended.

[g] 4 respondents were not captured: 3 include vitamin D in multivitamin or with calcium; 1 reported different units (pill vs. IU).

[h] 5 respondents were not captured: 2 include vitamin B12 in multivitamin; 3 take oral vitamin B12 while their recommendation is IV shots.

[i] 1 respondent is not adherent to the recommended supplementation due to high blood levels.

Table 4. Barriers to adherence identified by the respondents

	n	%
Difficult to take recommended supplements, *N*=137		
No	71	51.8
Yes	66	48.2
Barriers:		
Forgetting	28	42.4
Side effects	14	21.2
Too expensive	4	6.1
Difficult to find the recommended supplements	2	3
Confused by care provider's instructions	1	1.5
Other[a]:	17	25.8
Unpleasant taste/flavor	6	9.1
Chewing/swallowing difficulty	4	6.1
Supplement timing issue	3	4.5
Large dose	3	4.5

Sample size (*N*) reflects the number of respondents responded to the questions.

[a] Other barriers were listed if reported by more than one respondent.

Table 5. Micronutrient supplement purchase methods and choosing factors

	n	**%**
Ways to purchase supplements, *N*=136		
Purchased as OTC supplements[a]	73	53.7
Purchased through the internet	52	38.2
Purchased as prescription items	6	4.4
Purchased from my physician	3	2.2
Variety of methods	2	1.5
Factors influencing supplement choices, *N*=137		
Bariatric branded supplements	33	24.1
Recommended by care provider	31	22.6
Costs	28	20.4
Availability	14	10.2
Recommended by support groups	6	4.4
Other[b]:	25	18.2
Vitamin/mineral composition of supplements	7	5.1
Supplement forms	7	5.1
Pill size/easy to swallow	5	3.6
Organic/whole food based/other ingredients	4	2.9
Flavor	3	2.2
Personal research	3	2.2
Brand reputation	2	1.5

Abbreviation: OTC, over the counter

Sample sizes *(N)* reflect numbers of respondents responded to the questions.

[a] Includes pharmacy, drug store, nutritional supplement store, and convenience store.

[b] Other factors were listed if reported by more than one respondent.