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ORIGINAL CONTRIBUTIONS

Bariatric Nutrition Guidelines for the Indian Population

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Abstract
Background Bariatric surgery numbers have seen a sharp rise in India in the last decade. A country known for its undernourished population has seen economic growth and with it, greater influence of western culture and foods. The obesity epidemic is on the rise here and India is one of the 10 most obese nations of the world being second only to China in the number of type 2 diabetes. Nutritionists in India often rely on recommendations and guidelines meant for the Caucasian population. Religious and cultural practices influence the dietary habits and patterns of the Indian population to a great extent; because of which the nutritional requirements are very different. This document was put together with an aim to provide nutritionists with recommendations on how to manage the Indian bariatric patient.
Methods A bariatric nutrition round table meeting was initiated by the Centre for Obesity and Digestive Surgery (CODS) to bring together experts in the field of bariatric nutrition to review current data on nutritional deficiencies in the morbid obese and existing post-operative deficiencies and to formulate nutritional recommendations for bariatric/metabolic surgery specific to patients from India.
Results Percentage of nutritional deficiencies and reasons for the same were identified among the Indian population and recommendations were made to suit this particular population.
Conclusion It is recommended that all patients undergo compulsory pre-operative nutritional counseling and nutritional investigations and that nutritional follow-up be continued lifelong. In addition, long-term implications like hypoglycemia, dumping syndrome, sugar cravings, and weight regain, need to be picked up and managed efficiently. Most importantly, post-operative supplementation is a must irrespective of type of surgery.

Keywords Bariatric nutrition · Indian · Nutritional recommendations · Supplementation · Deficiency · Morbid obesity

Introduction

Bariatric surgery in India has grown phenomenally and is an established field already; however, bariatric nutrition is still in its nascent stages and requires guidelines to manage the nutritional requirements of bariatric surgery in the morbidly obese population.

Bariatric surgery impacts the nutritional status of patients in a number of ways from decreased food intake, food intolerances, food aversions, sugar cravings, to decreased absorption of nutrients, vitamins, and minerals.

Though the morbidly obese population may seem over nourished, the fact is that they are deficient in various nutrients owing to consumption of highly energy-dense fatty foods, lack of physical activity, prolonged use of certain medications, and a chronic diseased state. Therefore, it is important to screen bariatric patients prior to surgery and monitor them post-operatively. The Indian population has culturally different diets and hence, nutritional requirements. Therefore, guidelines and recommendations specific to this population are the need of the hour.

The bariatric nutrition round table meeting initiated by the Centre for Obesity and Digestive Surgery (CODS) was held to

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bring together experts in the field of bariatric nutrition from Asia (Appendix). The aims of the meeting were to:

- Review current data on nutritional deficiencies in the morbidly obese population. Review of data on existing post-operative deficiencies in those who have had bariatric/metabolic surgery.
- Formulate nutritional recommendations for bariatric/metabolic surgery specific to patients from India.

A total of 2740 Indian obese patients were studied and the percentage of common nutritional deficiencies pre-operative, 6 months post-operatively, and 1 year post-operatively are represented in Tables 1, 2, and 3, respectively. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Common Deficiencies Prevalent in Indian Population

Iron

Iron deficiency is very common in India. Almost 60 to 87 % of the Indian population has iron deficiency [1–3]. In pregnant women, it is more pronounced up to 99 % in some studies [2]. From our data, we found 43 % of the obese population iron-deficient pre-operatively.

Causes for Iron Deficiency in the Indian Populations

Dietary India is primarily a vegetarian nation, constituting about 70 % of the world population who adhere to vegetarian style diets. Vegetarian diets are encouraged by various ethical and religious beliefs. About 75 % are lactovegetarian, 25 % ova-lactovegetarians, and about 1 % are vegans [4]. Even though iron content of plant sources (non-heme) and animal sources (heme) is comparable, the absorption of heme iron is better than from non-heme iron sources—15–40 vs 1–15 %, respectively.

Staple foods in India mainly constitute iron-poor foods like wheat-based breads (rotis), rice, and lentils [4]. In addition, these popular foods contain high levels of phytates. Tea, which is also a very popular beverage in India and consumed in large amounts by majority of the population, contains tannins. Phytates and tannins hinder iron absorption [5]. An iron-rich cereal like ragi, which has lower phytate content (finger millet), is not commonly consumed here [6, 7].

Beans, another popular food item in India has only 2 % absorbability compared to soya bean, which has 30 % iron absorbability, which is less consumed [8, 9]. Fortification of vegetarian foods with iron is not a common practice in India as done in developed nations.

Causes of Deficiency After Surgery

Iron from the food reaches the stomach where it comes in contact with the gastric acid produced by the cells in the lining of the stomach wall. The gastric acid converts the ferric form to the ferrous form. Absorption of iron takes place mainly in the duodenum and proximal jejunum. Later, it is coupled with transferrin, the main iron transport protein, and delivered to the cells.

In surgeries like the sleeve gastrectomy, gastric bypass and duodenal switch gastric acid producing cells are reduced and gastric emptying time as well as intestinal transit time is reduced thus allowing lesser time for absorption, while the duodenum and jejunum are bypassed in the gastric bypass and duodenal switch.

In case of severe iron deficiency prior to surgery, it is recommended that IV iron supplementation be given prior to surgery and followed up post-operatively till optimum levels are achieved. In long-term nutritional follow-up, if iron levels continue to remain low especially in menstruating females and in those who develop adverse gastro-intestinal symptoms with oral supplementation—IV iron is recommended.

Common signs and symptoms of iron deficiency are fatigue and tiredness, hair loss, and/or brittle nails and dark circles under the eyes.

The recommended dietary allowance (*RDA*) *for Indian adult males 17 mg/day and Indian adult females 21 mg/day.*

The ferrous form of iron is preferred for supplementation post-bariatric surgery. Ferrous fumarate or other chelated forms of iron such as ferrous glycinate should be used.

The minimum recommended doses for iron supplementation post-bariatric surgery are 28–30 mg/day either ferrous fumarate or glycinate preferably with added ascorbic acid to enhance absorbability. *Level of evidence III*, *grade of recommendation C*

Table 1 Percentage of common pre-operative nutritional deficiencies in the morbidity obese population

Iron (μg/dl)	Vitamin B_{12} (pg/ml)	Calcium (mg/dl)	Vitamin D_3 (ng/ml)	PTH (pg/ml)	Protein (gms/dl)	Albumin (gms/dl)
43	56.7	11	35	42.45	10	9.38

Table 2 Percentage of nutritional deficiencies after bariatric/metabolic surgery at 6 months

Iron	Vitamin B_{12}	Calcium	Vitamin D_3	Secondary hyperparathyroidism	Protein	Albumin
31	37	9.1	6.7	21.6	22.4	14

Doses can be altered according to patient reports based on professional judgment. Iron supplementation needs to be used with caution in thalassemia and the first trimester of pregnancy.

Vitamin B_{12}

Vitamin B_{12} deficiency is common among the Indian population. Various studies have reported deficiency rates ranging from 35 to 75 % [10–13]. From our data, we found 56.7 % of the obese population were vitamin B_{12} deficient pre-operatively.

Causes for Vitamin B_{12} Deficiency in the Indian Populations

Dietary Vegetarianism is a way of life in India [14]. Vitamin B_{12} is produced in nature only by vitamin B_{12}-producing micro-organisms; humans must receive vitamin B_{12} solely from the diet [15]. Non-vegetarians get their vitamin B_{12} from meat, and lacto-ovo vegetarians get vitamin B_{12} from milk, dairy products, and eggs. However, in India, the vitamin B_{12} obtained from meat is marginal, as most of the population cannot afford the luxury of consuming meat on a daily basis [14, 16].

Plant sources of vitamin B_{12} are vegetables grown organically that have been fertilized with manure. Vitamin B_{12} from special microbially fermented products could be used by vegans but the bio availability is still under question [10, 14]. Refsum et al. suggest that there could be a genetic influence too contributing to the low B_{12} deficiency among Asian Indians [10].

Causes of Deficiency After Surgery

Vitamin B_{12} is a water-soluble vitamin and exists in several forms and contains the mineral cobalt [1–4]; hence, compounds with vitamin B_{12} activity are collectively called as "cobalamins." Two forms: adenosylcobalamin and methylcobalamin are active in human metabolism.

Vitamin B_{12} in food is protein bound and liberated from food protein by an active mechanism in the stomach where it binds to a salivary R-binder (family of haptocorrins). It is released again in the upper small intestine and attaches to the intrinsic factor (IF). IF is produced by the parietal cells of the stomach. The vitamin B_{12}-IF complex proceeds to the lower end of the small intestine, where it is absorbed by specific ileal receptors [17].

In surgeries like the sleeve gastrectomy, the duodenal switch there is reduced gastric acid production as well as reduction of intrinsic factor as there is reduction in the number of parietal cells due to the resection of the stomach. In the gastric bypass, food enters only the upper part of the stomach bypassing majority of the stomach cells which produce the intrinsic factor.

Signs and symptoms of mild vitamin B_{12} deficiency are similar to those of iron deficiency like fatigue, weakness, and tiredness; in moderate deficiency, tingling or numbness in fingers or toes, muscle weakness, and or muscle pain. In cases of severe vitamin deficiency, symptoms like ataxia and memory loss are noticed.

RDA for adult Indian males and females is 1 mcg.

Due to lack of or reduction in intrinsic factor post-bariatric surgery, vitamin B_{12} should be administered through a medium where it can be directly absorbed into the blood stream. In cases of severe deficiency, 500 to 1000 mcg of vitamin B_{12} should be administered intramuscularly at least every fortnightly. Sublingual or nasal administration of 1000–1200 mcg vitamin B_{12} is recommended as a maintenance dose. *Level of evidence III and grade of recommendation C*. Frequency should be increased depending on patient requirement and professional judgment.

Vitamin D_3

Vitamin D_3 deficiency rates of 44–90 % have been reported in the Indian population [18–20]. From our data, we found 35 % of the obese population vitamin B_{12} deficient pre-operatively.

Causes for Vitamin D_3 Deficiency Among the Indian Population

Lifestyle and Clothing Several mechanisms have been proposed such as lack of skin exposure to sunlight due to religious and social customs, modernization leading to sedentary lifestyles, more time spent indoors, and skin pigmentation [21–24].

Table 3 Percentage of nutritional deficiencies after bariatric/metabolic surgery at 1 year

Iron	Vitamin B_{12}	Calcium	Vitamin D_3	Secondary hyperparathyroidism	Protein	Albumin
21.9	44.5	6.9	7.5	23	24.8	14.8

Dietary Vegetarian diets, low calcium intake, high phytates, and high fiber intake, as well as genetic pre-disposition have also been stated as causes for vitamin D deficiency [20, 22].

Pregnancy Repeated unplanned and unspaced pregnancies have also been cited as one of the reasons of vitamin D_3 deficiency among pregnant mothers and the fetus [23, 25].

Bioavailabilty There is decreased bioavailability of vitamin D_3 from cutaneous and dietary sources due to deposition in body fat compartments [26]. There is a very delicate interplay between calcium, vitamin D_3, and PTH. Low vitamin D levels leads to decrease in dietary calcium absorption from the intestine. As blood calcium ions decrease parathyroid hormone (PTH) levels increase in order to maintain the blood calcium ions by reabsorption from kidney or bone resorption or conversion of vitamin D to an active form. Vitamin D_3 deficiency is a precursor of metabolic bone disease in most patients as calcium deficiency would take years to manifest.

Causes of Deficiency Post-Surgery

Vitamin D is mainly absorbed in the jejunum and ileum; therefore, procedures that bypass these sites will cause malabsorption of vitamin D. In the Roux-en-Y gastric bypass and mini-gastric bypass, the duodenum and jejunum are bypassed; there is also delayed mixing of bile juices due to the creation of the Roux limb which affects the absorption of vitamin D. In the duodenal switch, due to the bypassing of a large part of the small intestine and reduced absorption area, approximately 72 % of fat is malabsorbed, affecting the absorption of all fat-soluble vitamins and minerals including vitamin D [27].

Vitamin D_3 deficiency can be asymptomatic and therefore mostly goes undetected. However, common signs and symptoms are muscle weakness and/or muscle pain and muscle twitching.

RDA for vitamin D for Indian adults is 400–800 IU/day.

In cases of severe deficiency, 300,000 IU of cholecalciferol should be administered intramuscularly weekly or fortnightly for a duration of 6–8 weeks. However, oral administration of cholecalciferol in doses of 30,000–60, 000 IU should be administered either weekly or fortnightly as a maintenance dose. *Level of evidence III*, *grade of recommendation C*.

Toxicity of vitamin D_3 can cause hypercalcemia, which can lead to adverse effects on the heart, kidney, gastrointestinal tract, and central nervous system. Treatment of vitamin D_3 toxicity is discontinuation of intake vitamin D and calcium supplementation, a diet with low calcium and phosphorus content, intravenous hydration with saline, loop diuretics, glucocorticoids, calcitonin, and bisphosphonates [28].

Calcium

Causes of Calcium Deficiency Among the Indian Population

The rate of dietary calcium deficiency has been reported between 8 and 40.6 % across different age groups [18]. From our data, we found 11 % of the obese population vitamin B_{12} deficient pre-operatively.

Dietary Diets rich in phytates, present mainly in foods commonly consumed by the Indians such as wheat chapattis, beans, and legumes, retards the absorption of calcium from the gut [24, 29]. Studies conducted among the Indian population report an overall low dietary calcium intake, particularly during early growing years [30, 31].

Calcium is absorbed in all parts of the small intestine but the most rapid absorption takes place in the duodenum in the presence of an acidic pH. In periods of low calcium intake, active transport in the duodenum and proximal jejunum occurs that is controlled by the action of 1,25-dihydroxy vitamin D. Vitamin D enhances the uptake of calcium at the brush border of the intestinal mucosal cells by an incompletely understood mechanism. In periods of high calcium intake, passive transport occurs that is independent of vitamin D. It occurs along the entire length of the small intestine.

Causes of Deficiency Post-surgery

In surgeries like the gastric bypass and the duodenal switch, the most efficient calcium absorption sites are bypassed. Calcium deficiency also generally tends to go undetected as it is asymptomatic; however, some signs and symptoms are muscle cramps, numbness, and tingling in hand and feet and stress fractures.

RDA for calcium for Indian adults is 600 mg/day.

Calcium citrate is preferred over calcium carbonate as bioavailability is better as reported in a meta analysis [32]; 1000–1200 mg of calcium citrate is recommended post-bariatric surgery preferably administered in doses of not more than 500 mg at a time. *Level of evidence III*, *grade of recommendation C*.

Toxicity Very high intake of calcium (more than 2000 mg/day) especially with high levels of vitamin D is a potential cause of hypercalcemia. This may lead to renal insufficiency, vascular and soft tissue calcification, hypercalciuria, and kidney stones. High intake of calcium from supplements, but not foods, has been associated with increased risk of kidney stones [33]. High calcium intake can cause constipation.

Folic acid

Folic acid deficiency rates of 16–41 % have been reported in the Indian population [1, 34].

Causes of Folic Acid Deficiency in the Indian Population

Dietary Folic acid needs to be continuously replenished in the body; hence, a poor diet that is lacking in fresh fruits and vegetables will cause folic acid deficiency. Moreover, fortification of foods with folic acid is not a common practice in India [35].

Alcoholism Alcohol interferes with the metabolism of folic acid; therefore, dependence on alcohol will lead to folic acid deficiency.

Increased Need Pregnant women or those that are planning to conceive require a higher intake of folic acid.

Causes of Deficiency Post-Surgery

Folic acid is stored in small amounts in the body and requires constant replenishment; therefore, even though folic acid is primarily absorbed in the jejunum, reduced food intake, which is a result of all types of bariatric surgery, can cause folic acid deficiency. Folic acid deficiency is mostly asymptomatic and somewhat similar to vitamin B_{12} deficiency characterized by muscle weakness, irritability, and memory loss.

RDA for folic acid for Indian adults is 200 mcg/day.

In case of severe folic acid deficiency, 400 mcg in addition to a daily adult multivitamin supplement is recommended post-bariatric surgery. *Level of evidence III*, *grade of recommendation C*

Thiamine (B_1)

It is uncommon to find thiamine deficiency except in alcoholics or underfed breast-fed infants [36, 37].

Causes of Deficiency in the Indian Population

Dietary and Cooking Methods Thiamine deficiency or beriberi was a huge problem in developing countries like India; however, interventions such as under-milling of rice has eliminated this problem. Excessive use of refined cereals or highly milled rice in as well as excessive washing and cooking leads to loss of thiamine [37].

Cause of Deficiency Post-Surgery

Thiamine is a water-soluble nutrient that is absorbed by the proximal jejunum. Thiamine is not stored in the body and requires constant replenishment. Excess is excreted out through urine. Reduced food intake, food aversions, and food intolerances which are fairly common post-bariatric surgery can cause thiamine deficiency. Prolonged and persistent vomiting is an indication for thiamine supplementation without biochemical evaluation [38] (http://www.zinc.org/info/zni_india_program#Zn Deficiency in India). Bariatric beriberi can also develop in post-operative who are given infusion containing dextrose without vitamins [27].

Thiamine deficiency is of particular concern as it most often goes undetected or is confused with vitamin B_{12} deficiency and if goes untreated, can cause irreparable nerve damage.

Polyneuropathy (burning of feet at night, muscle soreness, cramps in lower extremities), paresthesia, and paraplegia are characteristics of thiamine deficiency. Acute thiamine deficiency can lead to Wernicke encephalopathy that causes oculomotor dysfunction, ataxia, and mental confusion. It may also lead to Korsakoff's psychoses that cause disorientation and memory loss [38].

RDA for thiamine for adult males is 1.2 mg/day and adult females is 1.1 mg/day.

It is recommended that in the immediate post-operative phase, all patients receive an exclusive B-complex formulation at least for 1 month post-operatively in addition to a complete multivitamin formula.

In cases of severe thiamine deficiency or in cases of persistent vomiting, intramuscular or intravenous administration is recommended.

Other Micro-nutrients

Zinc

It has been reported that approximately 26 % of the Indian population is at a risk of zinc deficiency [39, 40] (http://www.zinc.org/info/zni_india_program#Zn Deficiency in India).

Causes of Deficiency in the Indian Population

India has a high amount of zinc-deficient soils, resulting in zinc deficiency in its population. In addition, this deficiency is aggravated as the Indian staple diet is mainly cereal based [39, 40] (http://www.zinc.org/info/zni_india_program#Zn Deficiency in India).

Cause of Deficiency Post-Surgery

Zinc is a fat-dependent mineral and therefore, bariatric surgeries that cause fat malabsorption will also cause malabsorption of zinc. Malabsorptive surgeries like the biliopancreatic

diversion, duodenal switch, and long limb gastric bypass will cause deficiency of zinc. It has also been reported by some authors that Roux-en-Y gastric bypass also causes zinc deficiency [41, 42].

RDA for Indian adult males is 12 mg/day and females is 10 mg/day.

Deficiency symptoms are hair loss, skin lesions, taste alterations, and delayed wound healing [42–45].

Copper

The rate of copper deficiency among the Indian population has been reported between 2.7 and 35 % [46, 47]. Overt copper deficiency is extremely rare in the general population, is seen mainly in specific clinical conditions like prolonged TPN, premature or malnourished infants, and malabsorptive surgeries [48].

Causes of Deficiency Post-Surgery

Copper is mainly absorbed in the duodenum and to some extent, in the stomach and ileum. Gastric acid is required to free copper ions from food [49]. Therefore, in surgeries like the sleeve gastrectomy, gastric bypass, and duodenal switch, patients are at a risk of copper deficiency. Various studies have reported deficiency of copper in patients post-gastric bypass surgery [49–51]. Deficiency symptoms anemia and neutropenia are the most striking abnormalities of copper deficiency [52, 53].

The RDA for copper is 2 mg/day.

Selenium and Magnesium

Selenium deficiency is rare and is generally seen in specific clinical condition and patient groups such as prolonged parental nutrition, dialysis, inflammatory diseases, alcoholics, and strict vegetarians and vegans.

The RDA for selenium for Indian adult males is 36 μg and for Indian adult females is 26 μg.

Magnesium deficiency is also not found in the Indian population, unless under abnormal diseased conditions or a malabsorptive syndrome.

RDA for magnesium for Indian adult males is 340 mg/day and for Indian adult females is 310 mg/day (http://nutritionfoundationofindia.res.in/Crnss_New/update_jul_06.pdf; http://icmr.nic.in/final/RDA-2010.pdf).

Deficiency symptoms include muscle stiffness, muscle cramps, muscle pain, and hypocalcemia [54].

Few studies have also reported deficiencies of trace elements such and selenium and magnesium in malabsorptive procedures like the biliopancreatic diversion/duodenal switch (BPD/DS) as well as Roux-en-Y gastric bypass [55].

It is recommended that in order to prevent deficiencies of these micro-nutrients, all patients receive a complete multivitamin + mineral supplement. In malabsorptive procedures like the long limb Roux-en-Y gastric bypass and BPD/DS, it is recommended that these micro-nutrients be evaluated every 6 months. The dose of the multivitamin + mineral formula should be increased to 200–400 % of the daily value in these patients to prevent deficiencies.

Fat-Soluble Vitamins

Vitamin A and E deficiency

Vitamin A and E deficiency is still a public health concern among the lower socio-economic strata of society in India and the main cause dietary deficit. Studies among children have reported 88 % of vitamin A deficiency and 12–90 % having vitamin E deficiency [56, 57].

Vitamin A deficiency can cause xerophthalmia, night blindness, anemia, and reduced immunity and characteristics of vitamin E deficiency are peripheral neuropathy, ataxia, and anemia [58, 59]. No data was available on vitamin K deficiency among the Indian population.

Purely malabsorptive procedures cause deficiencies of fat-soluble vitamins like A, E, and K; however, even patients undergoing Roux-en-Y gastric bypass procedure may be at risk [27].

It is recommended that patients undergoing malabsorptive procedures be screened for these vitamins pre-operatively and evaluated at every 6-month intervals. In the absence of deficiency, a single dose of intramuscular injection of vitamins A, E, and K can be administered in order to maintain normal levels. A recommendation of 50,000 IU of vitamin A every 2 weeks and 500 mg of vitamin E daily, among other supplements, was suggested to correct most cases of deficiency [27].

Protein

Causes of Protein Deficiency in the Indian Population Dietary

Indians are primarily vegetarians consuming plant-based proteins. These plant proteins need to be consumed in the right combination (cereals + pulses) or else they will be incomplete in essential amino acids like lysine and tryptophan.

Hydrochloric acid from the stomach, along with pepsin, breaks dietary protein into smaller polypeptides. These are further broken down by pancreatic and intestinal enzymes which are finally broken down to amino acids and absorbed along the entire intestinal tract.

Causes of Deficiency Post-Surgery

Since protein is absorbed across the entire intestinal tract, protein deficiency is rare in most bariatric procedures other than in malabsorptive procedures such as duodenal switch, biliopancreatic diversion, and long limb gastric bypass.

Protein malnutrition occurs due to a variety of reasons namely lack of intake, food intolerance and food aversions, socio-economic status, vomiting, and diarrhea; therefore, most bariatric patients will be at a risk of protein deficiency [36].

The most recognizable signs of protein deficiency are hair loss, loss of muscle tone, and muscle wasting. Severe protein deficiency can also result in oedema or even liver cell failure in extreme cases.

The RDA for Indian males and females is 1 g/kg body weight.

Post bariatric surgery, the protein intake should be calculated as 1–1.5 g/kg ideal body weight. However, in a malabsorptive procedure such as the duodenal switch, biliopancreatic diversion and long limb gastric bypass protein intake should be calculated as 1.5–2 g/kg ideal body weight. *Level of evidence III*, *grade of recommendation C*.

Protein provided should be of high biological value and should be easily digested and absorbed. As overall food intake and quantity decreases post-bariatric surgery, emphasis should be on providing optimal amount of protein via supplementation and diet.

Pre-Operative Protocol

Table 4 represents the recommended protocol for pre-operative consultation/evaluation. Table 5 lists the pre-operative investigations are recommended in order to identify nutritional deficiencies.

In case of malabsorptive surgeries such as duodenal switch, limb lengthening recommended additional tests. Table 6 lists the recommended pre-operative nutritional tests for malabsorptive procedures.

Pre-Operative Diet Recommendations

Pre-operatively, it is essential that all patients follow a high protein, low carbohydrate diet for at least 7–10 days. The diet is essential as it results in decreasing the size of the liver and helps the patients prepare for nutritional restriction post-surgery. Pre-operative diet would ideally include a low carbohydrate intake 1000 kcals or less, a high protein intake approximately 75–80 g protein/day, and plenty of low-calorie fluids.

This diet needs to be modified in special conditions such as

Diabetics The pre-operative diet is restricted in calories and carbohydrates; hence, diabetics, especially those on insulin, should be counseled to check blood glucose levels frequently to avoid hypoglycemia. A consultation with their

Table 4 Recommended protocol for Pre-operative consultation/evaluation

Dietary Evaluation	• 24 hour diet recall • Food frequency • Smoking and use of tabacco products • Consumption of alcohol	• This is a must in order to gain insight of the current food pattern and behavior • An approximate quantitative and qualitative assessment of the food intake is possible with a thorough diet recall • Helps to identify volume eaters and sweet eaters • Leading questions such as 'how long to take to complete a meal' are justifiable in order to understand eating habits of the patients • All of this information plays a vital role in deciding the type of procedure to be undertaken as well as to ensure better dietary counseling-operatively
Psychological Evalauation	• Mood disorder • Anxiety disorder • Schizophrenia • Personality disorders • Eating disorders –Emotional eating –Binge eating –Night eating syndrome –PraderWilli syndrome • Adjustment disorder • Substance Related Disorders • Conitive ability	• In order to rule out contra indication to bariatic surgery (major psychiatric disorder) • Also important to assess compliance level of patient post surgery • Important in order to assess need of additional support post surgery, further counseling or full psychological evaluation
Biochemical assessment for nutritional deficiencies	• Complete blood and radiological investigation • Nutritional assessment	• Rule out any underlying medical conditions • Cross referrals if required at this stage • Commence supplementation incase of deficient state

Table 5 Recommended pre-operative nutritional profile

• Hemoglobin, serum iron, serum ferritin, % saturation
•Serum calcium, ionic calcium, PTH, 25 Di-hydrocholecalciferol
• Folic acid, homocysteine, vitamin B_{12}, uric acid
• Folic acid, serum albumin, serum globulin, A/G ratio

diabetologist/endocrinologist is critical in order to reduce the insulin and oral hypoglycemic agent requirements.

Patients with Compromised Renal Function High biological value proteins should be encouraged. Approximately 0.8–1 g/kg ideal body weight protein should be provided. Amount of protein to be restricted should be based on urinary creatinine clearance, serum creatinine, and serum albumin. In case of electrolyte imbalance, potassium and sodium restriction may be necessary. Fluid intake may be restricted in these patients; hence, one to needs to calculate intake as fluid intake = urine output (previous 24 h)+500 ml

Patients with Liver Disease Close monitoring of the protein and albumin levels is needed in these patients. Goal is to provide adequate protein and avoid severe protein restriction. Approximately 1.0–1.5 g/kg body weight protein should be provided. Sodium and fluid restriction needs to be evaluated in cases of ascites and hyponatremia.

Patients with Hyperuricemia Patients that have high uric acid levels should be counseled to avoid non-vegetarian forms of protein and purine-rich foods. Fluid intake should be encouraged.

Cardiac Patients Fluid and salt restriction has to be accounted for in these patients.

Post-operative care

Diet progression

Immediate post-op stage

Days 1 and 2 post-operatively, patients should be on clear liquids only to assess tolerance of oral intake. Start with 50 cm^3/h and then progress accordingly. Monitor the urine output in patients with renal and cardiac disorders.

Table 6 Recommended pre-operative nutritional tests for malabsorptive procedures

•Vitamins A, K, E
• Magnesium, zinc, copper, selenium
• Thiamine

Early Post-Op Stage

Day 3 onwards, patients progress on to a full liquid diet. At this stage, protein supplementation should commence. It is important to counsel patients regarding the choice of liquids—emphasis should be on nutritious liquids rather than sugary liquids. Protein supplements, low-fat dairy drinks, soy milk, pulses, and dals should be prioritized. Soups and vegetable juices come next and lastly, fruit juices with no added sugar. Sugary drinks, flavored syrups, carbonated beverages, and alcohol should be strictly prohibited. The quantity here can be stepped up to as much as the patient can tolerate. The patient should be advised against gulping fluids.

Day 16 onwards, patients can gradually introduce soft-textured foods in the diet. Foods that do not require too much chewing and those that are soft and moist should be introduced at this stage. Soft-textured foods, overcooked vegetables, well-cooked rice preparations, semolina and broken wheat preparations, porridges, cottage cheese, scrambled or boiled egg whites, baked/steamed fish, chicken mince, or chicken shreds can be introduced at this stage. Foods that should be avoided at this stage are hard fruits with seeds, nuts, breads, tough meats, and stringy vegetables.

Late Post-Op Stage

A regular low-fat diet is encouraged by the end of the month that includes all the food groups with priority to protein-rich foods. Vegetarian patients should be encouraged to continue with protein supplements till about 3 months post-operatively.

Post-Operative Follow-Up Protocol

Table 7 represents the post-operative follow up protocol.

Common Complaints in the Immediate Post-Op Phase

Nausea and Vomiting. The most common complaint of patients in the immediate post-op phase is nausea and vomiting and the most common cause is gulping of liquids/foods and increased speed of food/liquid intake.

However, persistent vomiting should be investigated further and referral to the primary surgeon should be given at the earliest. Supplementation with thiamine is a must in such cases in order to prevent B1 deficiency.

Food Intolerances and Aversions. In the immediate post-op phase, it is quite common for patients to have intolerance to certain foods depending on the type of surgery. Patients should therefore be encouraged to stick to

Table 7 Post-operative follow-up protocol

1 month	• Weight check
	• Dietary assessment
	• Progression to full diet
3 months	• Weight check + full body consumption
	• Check on nutritional profile
	• Check on compliance with supplements
	• Dietary evaluation
	• Monitor and check on medication and co-morbid conditions
6 months	• Same as 3 months + check for any long term complications- nutritional deficiencies, hypoglycemia, weight regain, etc.
1 year	• Same as 6 months + check for any long-term complications—nutritional deficiencies, hypoglycemia, weight regain, etc.
Yearly follow up	• Same as 1 year + check for any long-term complications—nutritional deficiencies, hypoglycemia, weight regain, etc.

common foods during this period. Those foods that do cause discomfort should be discontinued and tried again after a week's gap.

Bloating. This could be a result of gulping liquids or use of straw to consume liquids. All gaseous foods such as legumes and whole pulses, could cause bloating and should be restricted in such cases.

Constipation. Constipation/hard stools could result from sudden decreased intake of food and fluid. Patients who are immobile or have restricted movement are also more prone to constipation. Patients should be encouraged to sip liquids through the day. Fiber supplements should be used sparingly at this immediate post-op phase as it may aggravate the condition and also cause the smaller stomach pouch to fill up quickly leaving no space for food intake. Hence, liquid paraffin should be used.

Supplementation Post-Operatively

Supplementation should commence within a week to 15 days of the surgery depending on the tolerance of the patient and no later than 1 month after the surgery. Compulsory supplements are protein, complete adult multivitamins, calcium, and iron. Other supplementation should include those nutrients that were found deficient during the pre-operative phase. Table 8 lists the recommended supplementation post-operatively.

Long-Term Implications

Hypoglycemia This is one of the most devastating sequelae of some bariatric surgeries but also one that can be easily avoided by simple dietary modification. A thorough dietary recall is required and preferably a 3-day 24-h recall can help in gauging the food intake. A complex carbohydrate diet plan is sufficient to prevent hypoglycemia-like symptoms in most patients. Both soluble and insoluble fiber should be encouraged. A simple instruction like gap between solids and liquids is essential to prevent "flushing" down of the food.

Dumping Syndrome This is mainly associated with the gastric bypass surgery and is a result of large high-calorie food intake especially sugary foods but not excluding fried, deep fried foods stuffs, and alcohol. Early dumping syndromes, which results immediately after consuming a high-calorie meal can cause bloating, abdominal cramps or pain, and diarrhea. Late dumping, which result within 1–2 h after

Table 8 Recommended supplementation post-operatively

Multivitamins Complete adult multivitamin	1 daily
Calcium Calcium citrate	1000 mg/day preferably to be taken in doses of 500 mg. To be taken at least 2 h apart from iron supplements
Iron Ferrous fumarate or glycinate	28–30 mg/day with added ascorbic acid
Vitamin D_3	• Severely deficient (less than 10 ng/ml) 60,000 IU oral granules every weekly (for 6–8 weeks)
Cholecalciferol Intramuscular injection or granules	• 30,000 IU IM injections weekly for 6–8 weeks Insufficient (10–30 ng/ml) 60,000 IU fortnightly for 6–8 weeks or 30,000 IU IM injections fortnightly for 6–8 weeks
Vitamin B_{12}	Severely deficient—weekly 500 mcg intramuscular injection
Methylcobalamine Intramascular injections or sublingual tablets or liquid	Insufficient—500 mcg intramuscular injections fortnightly or sublingual drops/tablets daily or every alternate days

consumption of a high-calorie meal cause sweating, dizziness, and a rapid heartbeat.

Hyperuricemia This may actually aggravate in the immediate post-operative period; hence, care should be taken to spot signs and symptoms and modify protein intake accordingly.

Weight Regain The most common non-surgical causes of weight regain are consumption of high-calorie foods, sugary drinks, liquid calories, sugar cravings, excessive alcohol intake, and hypoproteinemia. Vital in these patients is to identify the reason for weight regain and to treat accordingly. Surgical reasons for weight regain should be excluded. However, in patients where weight regain is due to non-surgical causes, rigorous dietary intervention is required. Dietary intervention should include introduction of complex carbohydrates and fiber and elimination of simple and refined sugars. Work in conjunction with a psychologist especially in cases of excessive alcohol intake and maladaptive eating habits. Physical activity should be promoted in these patients.

Recommendations

- A compulsory pre- operative nutrition counseling for all patients that are to undergo bariatric/metabolic surgery
- Pre-operative nutritional investigations are a must.
- A high-protein, low-carbohydrate, and low-fat diet should be recommended for at least 7 days prior to the surgery.
- Modifications should be made in the pre-operative diet in special cases.
- Compulsory protein, multivitamin, calcium, and iron supplementation post-operatively irrespective of type of surgery.
- Life-long nutritional follow-up is required.
- Look out for hypoglycemia, dumping syndrome, sugar cravings, and weight regain.
- Recognize signs and symptoms of nutritional deficiencies.

Conflict of Interest The authors declare that they have no competing interests.

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