Table of Contents

Weight Loss Surgery and Its Nutritional Implications..………………..……2
The Vitamin Deficiency…..………………………………………………......…3
***Essential Supplemental Components* Iron…..……………………………...…...6**
Vitamin B_{12}…...……………………………………………………………..…..7
The Other B Vitamins…………………………………………………….…..…9
Folate…......……………………………………………………………………..11
Fat Soluble Vitamins……………………………………………………………12
Vitamin C……..……………………………………………………………..….14
Trace Minerals……….....……………………………………………………...15
Concluding Remarks.…........………………………………………………...17
Bibliography………………./…………………………………………………..18
Appendix… *The Vitamin Formulary*……………………….....……………….21

Weight Loss Surgery and Its Nutritional Implications
By Michele Silano MA, MS,RD

More than half of the American population is now considered overweight. Of that percentage, one third is considered obese. In 2000, the total cost of overweight and obesity was estimated at $117 billion dollars. This amount is close to the total 10% allocated to US health care spending.[1] Morbid Obesity, know clinically as severe obesity, is a major public health risk. While obesity, of itself, is a risk factor, most mortality and morbidity is associated with its co-morbid conditions. These conditions have been outlined in the 1985 National Institutes of Health Consensus Conference and include hypertension, hypertrophic cardiomyopathy, hyperlipidemia, diabetes, cholelithiasis, obstructive sleep apnea, hypoventilation, degenerative arthritis, and psychosocial impairments.[2] [3] Fortunately, through weight loss surgery individuals with Morbid Obesity now have the opportunity to regain their health and lives instead of becoming just another mortality statistic.

There are different types of weight loss surgery currently available. The Roux -en - Y Gastric Bypass is considered the gold standard, as well as being the most common of these surgeries done in the United States.[4] The surgical procedure involves bypassing the gastric fundus, body and antrum, the duodenum, and a variable length of the proximal jejunum.[5] The effectiveness of the surgical procedure is premised on a high degree of malabsorption that occurs within the digestive tract as a direct result of the bypassed sections. The subsequent malabsorption is a condition that continues with a patient for the rest of their life. Current research has demonstrated an increased risk of associated nutritional deficiencies post operatively. These deficiencies include iron, vitamin B_{12}, calcium, and folic acid. The literature indicates that although weight loss surgeries may initially differ, long term vitamin/mineral supplementation requirements persist and become similar in the long term. In addition, the reduction in total caloric intake along with food intolerances continues to limit the ability to absorb many essential

---

1 Bevoni, L. Management of Adult Obesity. *Clinician Reviews.* 13(5): 56-62, 2003.
2 Hubert H.B., et al. Obesity as an independent risk factor in gross obesity. *Circulation.* 67: 968-977, 1983.
3 Health Implications of Obesity. NIH Consensus Development Conference Statement. *Ann Int Med.* 103: 1073-77, 1985.
4 Palmer JA, Marliss EB. The present status of surgical procedures for obesity. In: Nutrition in Clinical Surgery. Baltimore, MD: Williams & Wilkins: 281-292, 1980.
5 Sugarman HJ, Kellum JM, Engle KM, et al. Gastric bypass for treating severe obesity. *Am J Clin Nutr*. 55 (2, supp): 560s-566s, 1992.

nutrients. [6] Maintaining optimum levels of nutrition is essential after weight loss surgery, not only in the immediate post-operative months, but for a lifetime.

The Vitamin Deficiency

Vitamins are essential components for proper body maintenance or Homeostasis. They often function as antioxidants, hormones, coenzymes, gene transcription elements, while others have a reduction/oxidation cofactor role within the body. The type of metabolic function depends upon its chemical structure and tissue/cellular distribution.[7] A decreased level of one or several vitamins produces a negative effect on our body's ability to maintain homeostasis.

As defined by Combs, *a primary vitamin deficiency* is related to the failure to ingest sufficient amounts of a vitamin needed to meet physiological requirements. Whereas, a *secondary vitamin deficiency* is the failure to absorb or utilize a vitamin post absorptively. Once vitamin deficiencies and their related clinical signs appear it is usually the end result of a chain of events that starts with the diminution in cells and tissues of the metabolically active form of the vitamin. [8] If not corrected, the continued reduction in vitamin status leads to inevitable clinical symptoms of vitamin deficiency. Patients after weight loss surgery may suffer a combination of both primary and secondary deficiencies throughout their lifetime subsequent to a combination of poor dietary intake and absorptive issues.

The literature has sufficiently documented how patients after weight loss surgery will be at an increased vulnerability for nutrient malabsorption. However, malabsorption does not appear to be the only obstacle for achieving sufficient nutrient levels. Instead, there exists additional challenges. Research findings suggest that a decreased bioavailability of vitamins will occur because of a decreased absorptive surface[9], bacterial overgrowth, altered intestinal transit time of a meal[10], decreased gastric parietal cell function, achlorhydria of the pouch, as well as biochemical and metabolic changes. Other secondary contributing factors include

---

[6] Burge JC, Zorman Schaumburg J, Choban PS, et al. *Changes* in patients' taste acuity after Roux-en-Y gastric bypass for clinically severe obesity. *J Am Diet Assoc*. 95:666-670, 1995.

[7] [7] Combs GF. The Vitamins: Fundamental Aspects in Nutrition and Health. Academic Press, New York: p82, 1992.

[8] Ibid. p 86.

[9] Rodger EL, Douglass W, et al. Deficiency of fat soluble vitamins after jejunoileal bypass surgery for morbid obesity. *Amer J Clin Nutr.* 33:1208-1214, 1980.

[10] Combs GF. The Vitamins: Fundamental Aspects in Nutrition and Health. Academic Press, New York: p 73, 1992.

inadequate vitamin body reserves, insufficient intake levels of vitamin/mineral supplements, and or a noncompliance in taking multivitamins due to their expense.[11] Lastly, a decreased food intake, very common to these patients, is compounded with a suppressed appetite and the common side effects of vomiting and diarrhea. All of the above mentioned factors greatly enhance the occurrence of either a primary or secondary vitamin deficiency during the lifetime of a weight loss surgical patient.

Therefore, the vitamin supplement of choice for these individuals must be unique and tailored to accommodate their special daily requirements. The majority of the available vitamin and mineral supplements are based upon the RDAs and assume persons using these products will have a normal gastrointestinal physiology. The vitamin levels set by the RDAs fail to define optimal intakes for those persons with special needs as presented by gastric bypass surgery. Rogers et al. observed low levels of vitamin stores in his subjects despite routine multivitamin supplementation at levels that are twice the RDA. Furthermore, low levels of vitamins have been observed several years after surgery throughout the literature. Rhodes, et al. suggests that using the Optimum Daily Intakes (ODI) rather than the RDAs as a reference for vitamin and mineral supplementation after gastric bypass should be the standard guide instead of the RDAs.

Given a weight loss patient's subsequent decreased food intake, altered absorption, consumption of nutrient-depleted foods, and biochemical individuality, they need higher than average nutrient levels.[12] It is especially during the first year post operatively when patients will obtain most of their nutrient intake from supplements rather than food. According to a study by Boylan, et al. vitamin supplementation intake after gastric bypass surgery was significantly correlated with plasma vitamin levels and had a major impact on the vitamin status of subjects.[13] However, Brolin et al. reports that regular daily multivitamin supplements still do not offer reliable protection to patients against the development of deficiencies after weight loss

---

[11] Boylan M, Sugarman HJ, et al. Vitamin E, vitamin B-6, vitamin B-12, and folate status of gastric bypass surgery patients. *J Am Diet Assoc.* 88: 581, 1988.

[12] Rhode BM, MacLean LD. Vitamin and Mineral Supplementation after Gastric Bypass in Update: Surgery for the morbidly obese patient. FD-Communications: p4, 2000.

[13] Boylan M, Sugarman HJ, et al. Vitamin E, vitamin B-6, vitamin B-12, and folate status of gastric bypass surgery patients. *J Am Diet Assoc*. 88: 581,1988.

surgery.[14] Furthermore, despite a resolution of calorie malnutrition post operatively, current research indicates the continuance of vitamin and mineral malnutrition.[15] Thus, there exists the life long necessity to remain on an appropriate vitamin mineral supplementation as the only possible solution to addressing vitamin deficiencies.

Essential Supplemental Components

Iron

Gastric bypass circumvents the duodenum, where 50 percent of iron is normally absorbed.[16] Tovey, et al. found that iron deficiency was the most common nutrition problem encountered by gastrectomy patients 10 years after their surgeries. [17] Iron deficiency occurring after gastric bypass surgery has been substantially documented in the literature as being a direct result of malabsorption, inadequate dietary intake, and a diminished absorption of free iron due to decreased gastric acid section.[18] The hypochlorhydria state of the gastric pouch is presented as part of the research of Mason and Ito[19], as well as by Behrns et al.[20] Both noticed a markedly reduced acid secretion from the small upper pouch of gastric bypass patients. Essentially, it is the hypochlorhydria that prevents reduction of free iron and decreases the solubility of inorganic dietary iron, impairing absorption.[21]They report this factor as contributory to the iron deficiency observed after gastric bypass.

Postoperative changes in eating habits and food preferences may contribute to development of iron deficiency after surgery. For instance, it has been documented that red meat a common source of iron in the typical American diet, becomes a poorly tolerated food source after gastric bypass. Avinoah et al [22] reported a significantly higher incidence of iron, vitamin B_{12}, and folate deficiency in patients who had gastric bypass surgery and ate meat less than once per week versus

---

[14] Brolin RE. Et al. Multivitamin prophylaxis in prevention of post-gastric bypass vitamin and mineral deficiencies. *Int J Obes*. 15:661-668, 1991.

[15] Avinoah E, Ovnat A, Charuzi I. Nutritional status seven years after Roux-En-Y gastric bypass surgery. *Surgery.* 111: 137-142, 1990.

[16] Wright HK, Tilson MD. Postoperative Disorders of the Gastrointestinal Tract. Grune & Stratton, New York: p34, 1973.

[17] Tovey FI, Godfrey JE, Lewin MR. A gastrectomey population: 25-30 years on. *Postgrad Med J*. 66:450-6, 1990.

[18] Hocking MP, Vogel SB. Woodward's Postgastrectomy Syndromes. Saunders, Philadelphia: p156, 1991.

[19] Mason EE, Ito CC. Gastric bypass in obesity. *Surg Clin North Am*. 47: 1345-1354, 1967.

[20] Behrns KE, et al. Prospective evaluation of gastric acid secretion and cobalamine absorption following gastric bypass for clinically severe obesity. *Dig Dis Sci*. 39:315-320, 1994.

[21] Perdikis G, Redmond EJ, Hinder RA. Gastric Surgery in The Gastrointestinal Surgical Patient. Williams & Wilkins, Baltimore: 319, 1994.

[22] Avinoah E. et al. Nutritional status seven years after Roux-en-Y gastric bypass surgery. *Surgery*. 11:139, 1992.

patients who consumed meat more than once weekly. In contrast, Brolin et al. indicated no such difference and concluded that meat consumption did not affect the iron levels of his study's subjects. Instead, he attributes the onset of iron deficiency within the first 12 months postoperatively to the inability to metabolize and absorb dietary iron.

Lastly, excessive menstrual bleeding in females may become an additional factor contributing to iron deficiency. Women who have weight loss surgery are assigned an increased risk of iron deficiency since their stores are known to be lower than that of males, and blood loss during menstruation requires that they absorb more iron to prevent microcytosis and anemia.[23] Based on the literature, menstruating women are recommended to take iron supplements indefinitely after gastric bypass surgery. At present, it is not known whether the need for iron supplementation continues after menopause. Overall, iron malabsorption a result of any of the above mentioned factors can usually be resolved with oral supplementation above the RDA.

Vitamin B_{12}

Vitamin B_{12} plays a critical role in our metabolism functioning as two co enzymatic forms: adenosylcobalamin and methylcobalamin. Vitamin B_{12} is found in the tissues of animals and seldom in foods derived from plants. Persons consuming strict vegetarian diets or whose diets are deficient in Vitamin B_{12} foods, or have had a gastric restrictive procedure are more likely to have suboptimal levels.

Normally, cobalamin rich foods undergo acid and peptic hydrolysis in the stomach to liberate vitamin B_{12}. Once released, vitamin B_{12} is bound to R binders located in gastric juice, bile, and intestinal secretions. Pancreatic proteases then degrade R binders in the duodenum and permit vitamin B_{12} to combine with Intrinsic Factor (IF). The IF-vitamin B_{12} complex then is bound to specific receptors in the distal ileum where absorption occurs.

The Roux – en - Y gastric bypass procedure disrupts the key steps of Vitamin B_{12} absorption. Not only is there a decreased acid and pepsin digestion of protein bound cobalamins from foods, but also an incomplete release of vitamin B_{12} from R Binders, and a decreased availability of Intrinsic Factor to form IF-Vitamin B_{12}

[23] Yale CE, Gohdes, PN, and Schilling, RF. Cobalamin absorption and hematologic status after two types of gastric surgery for obesity. *Amer J Hema*. 42: 64, 1993.

complexes. [24] The lack of IF results from atrophy of the gastric parietal cells. Subsequently, achlorhydria will present within the gastric pouch as a result of the cell's inability to produce the gastric acid. Malabsorption of this vitamin ultimately results in anemia between 2-7 years after loss of IF production. [25] In non weight loss patients, Vitamin B_{12} accumulates within the liver in amounts adequate to satisfy the nutritional needs of the person for a number of years. [26] This is contrasted to Vitamin B_{12} deficiencies occurring one year or more after gastric bypass in greater than 30% of patients 1 to 9 years after surgery.[27]

In respect to weight loss surgery, Vitamin B_{12} deficiency has been shown to also be a consequence of food no longer coming in contact with gastric intrinsic factor. Schilling and Behrns et al. theorized that the dietary cobalamin malabsorption after bypass surgery may be secondary to intrinsic factor deficiency. This is subject to ingested food bypassing the intrinsic factor producing portion of the stomach. Marcuard et al demonstrated that there exists a deficiency of luminal intrinsic factor after gastric bypass, a result of malabsorption from an Intrinsic Factor deficiency. [28] [29] Furthermore, the secreted intrinsic factor from the bypassed stomach may be exposed to pepsin degradation in the bypassed segment and to trypsin degradation at the jejunojejunal anastomosis before it has an opportunity to bind to biliary and dietary cobalamin. Schilling also mentions that free Intrinsic Factor is sensitive to proteolysis by enzymes, in contrast to Intrinsic factor bound to cobalamin, which is resistant. Therefore, the addition of Intrinsic factor to the multivitamin bound cobalamin supplementation may enhance the absorption of free cobalamin postoperatively.

The Other B Vitamins

Thiamin (*Vitamin B_1*), Riboflavin (*Vitamin B_2*), Niacin (*Vitamin B_3*), Pantothenic Acid (*Vitamin B_5*), Pyrodoxine Phosphate (*Vitamin B_6*), and Biotin are essential for the intermediary metabolism of carbohydrates, amino acids, and lipids.

---

[24] Kushner, R. Managing the Obese Patient after Gastric bypass surgery: A case report of severe malnutrition and review of the literature. *J Parenter Enteral Nutr*. 24 (2): 129, 2000.

[25] Combs,GF. The Vitamins: Fundamental Aspects in Nutrition and Health. Academic Press, New York: p 415, 1992.

[26] Ibid. p76.

[27] Kushner R. Managing the obese patient after bariatric surgery: A case report of severe malnutrition and review of the literature. *J Parenter Enteral Nutr*. 24 (2): 126-132, 2000.

[28] Marcuard SP, et al. Absence of luminal Intrinsic factor after gastric bypass surgery for morbid obesity. *Dig Dis Sci*. 34:8 p1241, 1989.

[29] Behrns KE, et al. *Prospective evaluation of gastric acid secretion and cobalamin absorption following gastric bypass for clinically severe obesity*. *Dig Dis Sci.* 39:319, 1994.

These vitamins function as coenzymes within the body. They are primarily absorbed within the proximal and distal small intestine via passive diffusion when at decreased levels within the body. Malnutrition secondary to inadequate dietary intake is the most important cause of deficiency of these vitamins. Boylan et al. cites an unusual and severe form of polyneuropathy to be a direct result from deficiency of B complex vitamins. [30] Unfortunately, there is limited available research on the majority of these B vitamins in relationship to their post surgical requirements after weight loss surgery. The following is a review of the literature on the B vitamins.

Thiamin is absorbed in the small intestine, primarily in the jejunum and ileum. However, it can also be absorbed by passive diffusion at higher concentrations. Stores of thiamine are limited due to its short half life, so that total body thiamine depletion can occur within 18 days following dietary restriction in healthy adults.[31] Vomiting on a daily basis and or a decreased dietary intake, not always admitted to by patients, is an excellent indicator of nutritional depletion and can result in both malnutrition and diminished vitamin status.[32] These factors in combination with a generalized decreased absorption of the vitamin within the intestines will act to deplete the stores quickly and often has been cited in the literature as causing symptoms associated with Wernicke Encephalopathy. There has been increased awareness and documentation on Warnock's Encephalopathy in morbidly obese surgically treated patients who have undergone a gastric restrictive surgery, including adjustable gastric banding. The research indicates that deficiency stems from a decreased pouch outlet that restricts intake and causes persistent vomiting.[33] Therefore, adequate supplementation from the onset postoperatively will reduce the risk of this vitamin deficiency.

Biotin is essential to our body's metabolism.[34] In fact, Biotin has been popularized by weight loss surgical patients as significant to promoting strong nails, healthy hair, and aiding in the treatment of seborrheic dermatitis often associated

---

[30] Boylan M, Sugarman, HJ, et al. Vitamin E, vitamin B-6, vitamin B-12, and folate status of gastric bypass surgery patients. *J Am Diet Assoc*. 88: 579, 1988.

[31] Ziporin ZZ, Nunes WT, Powell RC, et al. Thiamine requirement in the adult human as measured by urinary excretion of thiamine metabolites. *J Nutr*. 85:297-304, 1965.

[32] McLean LD, Rhode BM, Shizgal HM. Nutrition following gastric operations for morbid obesity. *Ann Surg*. 198 (3), 347-355, 1983.

[33] Sola E, Morillas, C, et al. Rapid Onset of Wernicke's Encephalopathy following gastric restrictive surgery. *Obesity Surgery.* 13: 661-662, 2003.

[34] Murray MT. Encyclopedia of Nutritional Supplements. Prima Health, California, p111, 1996.

with the overall decrease of B vitamins postoperatively. Limited research has documented that low levels of biotin exist in the plasma or urine of patients with partial gastrectomy or other causes of achlorhydria. [35] Subsequently, this impaired absorption of Biotin within the achlorhydric pouch of the weight loss patient would contribute to the physical symptoms of brittle nails, hair loss, and seborrheic dermatitis observed postoperatively.

The rate of Riboflavin absorption is proportional to intake and is enhanced in the presence of substantial stomach acid availability. Unfortunately, the postoperative patient experiences both decreased absorption due to non-existent acidic levels, as well as a diminished dietary intake of the vitamin. In addition Riboflavin deficiency has been related to Lactose Intolerance, a common dietary side effect of weight loss surgery patients, as well as a decrease in the enteric absorption of dietary Iron.[36] Thus, it is very likely that a weight loss surgical patient will be at a higher risk for riboflavin deficiency.

Lastly, high protein diets may increase the requirements for Vitamin B_6. Consequently, post operative patients are advised to increase their overall protein intake secondary to decreasing the risk of malnutrition a direct result of surgery. Furthermore, Boylan et al. reported that subjects taking low supplement amounts of B_6 were in the marginal or deficient status category at 6 and 12 months post-surgery. Whereas, those individuals with moderate to high supplemental intake of Vitamin B_6 exhibited adequate stores.[37] Lastly, Deitel recommends Vitamin B_6 secondary to its role in protein synthesis by the liver.[38]

Folate

Folates are important cofactors in the synthesis of amino acids, purines, and pyrimidines.[39] Dietary folate bypasses the duodenum, the primary site of folate absorption. However, folate absorption can still occur along the entire length of the small intestine with adaptation after surgery. [40] Folate deficiency postoperatively is often encountered in persons not regularly taking a multivitamin supplement, as

---

[35] [35]Combs GF. The Vitamins: Fundamental Aspects in Nutrition and Health. Academic Press, New York: p360, 1992.

[36] Ibid. p 304.

[37] Boylan M, Sugarman, HJ, et al. Vitamin E, vitamin B-6, vitamin B-12, and folate status of gastric bypass surgery patients. *J Am Diet Assoc.* 88: 583, 1988.

[38] Deitel M. Surgery for the Morbidly Obese Patient. Lea & Febiger, Philadelphia: p 111, 1989.

[39] Savage DG, Lindenbaum J. Folate-cobalamin interactions. In: Bailey LB, ed. Folate in Health and Disease. Marcel Dekker Inc, New York: p 237-285:1995.

[40] Elliot K. Nutritional considerations after bariatric surgery. *Crit Care Nurs Q*. 26: p133, 2003.

well as having a poor dietary intake. In addition, folate utilization can be impaired by depletion of zinc.[41]

Homocysteinemia is a risk factor for coronary, cerebral, and peripheral arterial occlusive diseases, as well as for carotid thickening. [42] One study indicated that subjects who took supplements containing the RDA for Folate had inadequate stores 6 months postoperatively. [43] A marginal folate deficiency induced by restrictive weight loss surgery could promote hyperhomocysteinemia, a condition that increases ones' risk for cardiovascular disease.[44] Borson-Chazot et al. observed that while gastroplasty improved the atherogenic profile of the morbid obese individual it increased the plasma homocysteine levels. Thus, jeopardizing the cardiovascular benefits of the surgery. The researchers concluded that prolonged folate supplementation is required to potentially reduce the risk factor post operatively. Lastly, numerous studies make the connection between folic acid and its relationship with vitamins B_{12} and B_6 to homocysteinemia and a person's nutritional status with respect to those vitamins.

The concern about the use of a high folate concentration in respect to postoperative weight loss patients is associated with the potential masking of macrocytic anemia linked to a vitamin B_{12} deficiency. The literature points out that this situation can be addressed with the addition of sufficient levels of Vitamin B_{12} accompanied with intrinsic factor. According to Kushner's review of the literature, the 1 mg of folate contained in all prenatal vitamins appears sufficient to prevent deficiency in postoperative weight loss patients.[45] In conclusion, the literature supports the use of high dosages of Folate to decrease the risk of anemia and cardiovascular disease related to elevated homocysteine levels after weight loss surgery.

Fat-Soluble Vitamins

Fat- Soluble vitamin deficiencies occurred in 76% of patients after jejunoileal bypass surgery as observed by Rodgers et al. He pointed to maldigestion and

---

[41] Combs GF. The Vitamins: Fundamental Aspects in Nutrition and Health. Academic Press, New York: p396, 1992.

[42] Ibid. pg 412

[43] Boylan M, Sugarman, HJ, et al. Vitamin E, vitamin B-6, vitamin B-12, and folate status of gastric bypass surgery patients. *J Am Diet Assoc.* 88: 584, 1988.

[44] Borson-Chazot F, Harthe C. et al. Occurrence of Hyperhomocysteinemia 1 year after gastroplasty for severe obesity. *J. Clin Endocrinol Metab*. 84 (2): 541-545, 1999.

[45] Kushner, R. Managing the Obese Patient after Gastric bypass surgery: A case report of severe malnutrition and review of the literature. *J Parenter Enteral Nutr*. 24 (2): 129, 2000.

malabsorption as the culprits of abnormally low Vitamin A levels in patients who had successfully lost 30% or more of their initial body weight than in those persons who had not lost as much. Fat- Soluble vitamins include vitamin A (in the forms of Retinol and Beta Carotene) and Vitamin E . Generally, patients have a tendency to consume very low fat diets to expedite weight loss efforts. Thus, these vitamins are of particular nutrition concern post operatively and pose an increased risk for fat malabsorption after surgery.

Vitamin A plays a significant physiological role within the body. Not only is this particular vitamin involved in vision function, it also stimulates growth hormone in pituitary cells along side thyroid hormone, it is involved in the regulation of gene transcription, embryonic development, drug metabolism, reproduction, bone metabolism (*vitamin A affects osteoclasts which are reduced in a deficiency state*), hematopoiesis (*studies have shown that supplemental Vitamin A increases iron status in anemic persons*), immunity, maintaining the normal health of skin, antioxidant and anticarcinogenic properties, and reducing the risk of cardiovascular disease.[46]

Vitamin A malabsorption can be due to a number of factors which are present in restrictive weight loss surgeries. These factors include diminished amounts of pancreatic enzymes and or intestinal enzymes for the conversion of B-carotene and retinal to retinol. In addition, it may be due to the decreased capability of the regenerating intestinal mucosa to re-esterify vitamin A for transport to the liver. Lastly, low Vitamin A serum levels can be due to impaired hepatic release of vitamin A. It is important to recognize that protein–calorie malnutrition can reduce the production of retinol-binding protein and suppress the release of Vitamin A from the liver. Furthermore, decreased levels of serum carotene have been noted as long as 12 to 15 months post operatively. Nyctalopia or Night Blindness, which resolved with oral vitamin A supplementation, has been reported.[47] In addition, some patients have demonstrated an unusual retinal pattern of depigmentation that has been associated with an inability to see at night.[48]

Similarly, Carotenoids are absorbed in the distal small intestine via micelle dependant passive diffusion. Evidence indicates that the enteric absorption of B-

---

[46] Combs GF. The Vitamins: Fundamental Aspects in Nutrition and Health. Academic Press, New York: pg 128-142, 1992.

[47] Toskes P, Dawson W, Fitzgerald C. et al. Retinopathy following jejunoileal bypass surgery for obesity. *Clin Res Abstr.* 27:456a, 1978.

[48] Brown GC, Fleton SM, Benson WE. Reversible night blindness associated with intestinal bypass surgery. *Am J Opthalmol.* 89:776-779, 1980.

Carotene may depend on the conditions of gastric acidity of the individual, as subjects with reduced gastric acid production showed lowered blood responses to test doses of B-carotene. This is significant to the weight loss surgical patients who experiences hypochlorhydria of the stomach pouch. Thus, the preferred form to achieve increased absorption would be the retinol form of Vitamin A.

Vitamin E is absorbed primarily within the medial small intestine by passive diffusion. Absorption is dependant upon the abundance of pancreatic juice and bile salts, as well as the presence of fat in the gut. Efficiency of absorption is reduced in the absence of normal levels of bile and pancreatic enzymes. Deficiency frequently develops in chronic malabsorption situations. Therefore, individuals unable to produce pancreatic juice or bile, demonstrate an impaired absorption of Vitamin E.[49]

Being a fat soluble vitamin, it is often assumed that vitamin E body stores are usually sufficient and relatively stable. This is not the case with weight loss surgical patients. In a study by Boylan, et al. a decreased Vitamin E plasma level post operatively was attributed to a decrease in the total level of plasma lipids after weight loss surgery, poor dietary intake, as well as those eating low fat diets.[50] In summary, the literature overwhelming indicates the need to orally supplement both Vitamin A and E in all postoperative patients in order to overcome losses due to malabsorption and poor dietary intake of these fat soluble vitamins.

Vitamin C

Vitamin C is essential to human nutrition, particularly because our bodies are unable to synthesize it. In general, the bioavailability of vitamin C is about the same from food or supplements and is dose dependant. Studies indicate that the efficiency of absorption declines at doses greater than 1,000mg.[51] Research has established that Vitamin C is beneficial in decreasing hypertension, atherogenesis, diabetic complications, while it also serves to boost immunity, has specific antioxidant properties, increases Iron and Vitamin E absorption, and helps in wound healing. One study conducted by Nanji et al observed a marked reduction in the levels of

---

[49] Combs GF. The Vitamins: Fundamental Aspects in Nutrition and Health. Academic Press, New York: pg 194, 1992.

[50] Boylan M, Sugarman HJ, et al. Vitamin E, vitamin B-6, vitamin B-12, and folate status of gastric bypass surgery patients. *J Am Diet Assoc*. 88: 582, 1988.

[51] Combs,GF. The Vitamins: Fundamental Aspects in Nutrition and Health. Academic Press, New York: pg 250, 1992.

Vitamin A and C by 50% in all patients during the early postoperative period.[52] As dietary intake has been shown to decrease postoperatively, the levels of Vitamin C also diminish due to the intolerance of the acidic nature of rich Vitamin C foods by patients.

Trace Minerals

Protein deficiencies combined with intolerance to certain foods, such as red meat, vegetables, or fresh fruit, may be responsible for the low serum and tissue levels of zinc, potassium, and magnesium. The chelated form of minerals tend to promote improved availability within the digestive tract after surgery.

Potassium interacts with Magnesium within many body systems. Its depletion occurs when the loss rate of potassium through urinary excretion, sweat, or the gastrointestinal tract (vomiting or diarrhea) exceeds the rate of potassium intake. Because vomiting is often associated with the initial post operative period after surgery due to a variety of factors, this trace mineral needs to be monitored for adequate status and adequately supplemented.

Magnesium deficiency on long-term follow-up has been reported in post operative weight loss patients.[53] It is second to potassium in terms of concentration within the body's cells. It works with Vitamin B_6 to regulate the body's enzymatic systems. Magnesium among its significant functions plays a prominent role in bone and mineral status, directly affecting bone cell function and hydroxyapatite formation and growth. Approximately 60 percent of the magnesium in the body is in the bone. [54]This is of particular concern, as the majority of weight loss surgical patients noted in the literature tend to be females. Therefore, Magnesium deficiency becomes an additional risk factor for post menopausal osteoporosis. [55]

Zinc is involved in several important catalytic activities that involve enzymes and hormones, as well as its importance with normal skin function. Research is limited in relation to Zinc status after weight loss surgery. Zinc deficiency is often associated with protein deficiency, increased body losses secondary to starvation, intestinal resection, and certain health conditions that include Diabetes Mellitus. All of these conditions causing a decreased intake and or utilization of zinc have been

---

[52] Nanji AA, Freeman JB. Gastric bypass surgery in morbidly obese patients markedly decreases levels of vitamins A and C and iron in the preoperative patient. *Am J Obes.* 9:177-179, 1985.

[53] Halverson JF. Metabolic sequel of gastric restrictive operations. *Proc Am Soc Bar Surg.* 1: 113-121, 1984.

[54] Murray, MT Encyclopedia of Nutritional Supplements. Prima Health, California: p 159, 1996.

[55] Stendiz-Lindberg G. et al. Trabecular bone density in a two year controlled trial of peroral magnesium in osteoporosis. *Magnes Res* 6: 155-163, 1993.

observed in weight loss surgical patients. Therefore, adequate zinc levels are essential for good health and immune function and also require adequate supplementation levels.

Concluding Remarks:

Requirements for fat-soluble and water-soluble vitamins, as well as trace minerals must be recognized and met to ensure optimal maintenance for the weight loss surgical patient. Further research is necessary to determine more accurately the requirements for each vitamin, as well as the effects that marked malnutrition, diminished dietary intake, negligible acid sections, decreased digestive enzyme content, substantial weight loss, and poor dietary compliance have on those requirements. Deficiency syndromes, especially of Iron, Thiamin, Folate, and Vitamin B_{12} may occur more rapidly after surgery and can only be detected through a patient's compliance with vitamin supplementation, dietary behavior, scheduled doctor visits, and routine testing. Measurement of blood levels may not be sufficient, as we still have a poor understanding of the relationship between levels and body stores in this population. Furthermore, weight loss surgical patients may still be at an increased risk of cardiovascular disease due to increased homocysteine levels if inadequate folate is provided in supplement form.

As the literature has indicated, vitamin deficient patients consuming high doses of vitamins/minerals had significantly higher plasma concentrations post operatively compared to their post operative counterparts who took levels comparable to RDA guidelines. Therefore, in order to avoid possible deficiencies the ODI's rather than the RDAs of vitamins should be followed when recommending vitamin supplementation to a weight loss surgical patient. Such guidelines were followed when developing this supplement formulary. Therefore, higher than average doses will ensure adequate support yet will not carry risk of toxicity due to the nature of their composition. In conclusion, vitamin deficiencies within this subgroup of individuals and their specialized nutritional requirements will not resolve without the administration of a specialized vitamin that is adaptive to their particular dietary issues postoperatively and beyond.

Bibliography

Avinoah E, Ovnat A, Charuzi I. Nutritional status seven years after Roux-En-Y gastric bypass surgery. *Surgery.* 111: 137-142, 1990.

Behrns KE, et al. *Prospective evaluation of gastric acid secretion and cobalamin absorption following gastric bypass for clinically severe obesity*. *Dig Dis Sci*.39:315-320, 1994.

Bevoni L. Management of Adult Obesity. *Clinician Reviews.* 13(5): 56-62, 2003.

Borson-Chazot F, Harthe C. et al. Occurrence of Hyperhomocysteinemia 1 year after gastroplasty for severe obesity. *J. Clin Endocrinol Metab*. 84 (2): 541-545, 1999.

Brolin RE. Et al. Multivitamin prophylaxis in prevention of post-gastric bypass vitamin and mineral deficiencies. *Int J Obes*. 15:661-668, 1991.

Brown GC, Fleton SM, Benson WE. Reversible night blindness associated with intestinal bypass surgery. *Am J Opthalmol.* 89:776-779, 1980.

Boylan M, Sugarman HJ, et al. Vitamin E, vitamin B-6, vitamin B-12, and folate status of gastric bypass surgery patients. *J Am Diet Assoc*. 88: 579-585, 1988.

Burge JC, Zorman Schaumburg J, Choban PS, et al. Changes in patients' taste acuity after Roux-en-Y gastric bypass for clinically severe obesity. *J Am Diet Assoc.* 95:666-670, 1995.

Campbell, NR. How safe are folic acid supplements? *Arch Intern Med*. 156:1638-1644, 1996.

Combs GF. The Vitamins: Fundamental Aspects in Nutrition and Health. Academic Press, New York, 1992.

Deitel M. Surgery for the Morbidly Obese Patient. Lea & Febiger, Philadelphia, 1989.

Elliot K. Nutritional considerations after Bariatric surgery. *Crit Care Nurs Q.* 26, (2): 133-138, 2003.

Flodin NW. Pharmacology of Micronutrients. Alan R. Liss, Inc., New York, 1988.

Halverson JF. Metabolic sequelae of gastric restrictive operations. *Proc Am Soc Bar Surg*. 1: 113-121, 1984.

Health Implications of Obesity. NIH Consensus Development Conference Statement. *Ann Int Med*. 103: 1073-77, 1985.

Hocking MP, Vogel SB. Woodward's Postgastrectomy Syndromes. Saunders, Philadelphia, 1991.

Hubert HB, et al. Obesity as an independent risk factor in gross obesity. *Circulation*, 67: 968-977, 1983.

Kushner, R. Managing the Obese Patient after Gastric bypass surgery: A case report of severe malnutrition and review of the literature. *J Parenter Enteral Nutr*. 24 (2): 126-132, 2000.

Marcuard SP, et al. Absence of luminal Intrinsic factor after gastric bypass surgery for morbid obesity. *Dig Dis Sci*. 34(8) p1238-42, 1989.

Mason, EE. Surgical Treatment of Obesity. W. B . Saunders Company, Philadelphia, 1981.

Mason EE, Ito CC. Gastric bypass in obesity. *Surg Clin North Am*. 47: 1345-1354, 1967.

McLean LD, Rhode BM, Shizgal HM. Nutrition following gastric operations for morbid obesity. *Ann Surg*. 198(3), 347-355, 1983.

Murray, MT Encyclopedia of Nutritional Supplements. Prima Health, California, 1996.

Nanji AA, Freeman JB. Gastric bypass surgery in morbidly obese patients markedly decreases levels of vitamins A and C and iron in the preoperative patient. *Am J Obes*. 9:177-179, 1985.

Palmer JA, Marliss EB. The present status of surgical procedures for obesity. In: Nutrition in Clinical Surgery. Williams & Wilkins, Baltimore: 281-292, 1980.

Perdikis G, Redmond EJ, Hinder RA. Gastric Surgery in The Gastrointestinal Surgical Patient. Williams & Wilkins, Baltimore, 1994.

Rhode BM, MacLean LD. Vitamin and Mineral Supplementation after Gastric Bypass in Update: Surgery for the morbidly obese patient. FD-Communications, p1-10, 2000.

Rodger EL, Douglass W, et al. Deficiency of fat soluble vitamins after jejunoileal bypass surgery for morbid obesity. *Amer J of Clin Nutr.* 33:1208-1214, 1980.

Savage DG, Lindenbaum J. Folate-cobalamin interactions. In: Bailey LB, ed. Folate In Health and Disease, Marcel Dekker Inc: New York: 237-285,1995.

Sola E, Morillas C, et al. Rapid Onset of Wernicke's Encephalopathy following gastric restrictive surgery. *Obesity Surgery*. 13: 661-662, 2003.

Stendiz-Lindberg G. et al. Trabecular bone density in a two year controlled trial of peroral magnesium in osteoporosis. *Magnes Res* : 55-163, 1993.

Sugarman HJ, Kellum JM, Engle KM, et al. Gastric bypass for treating severe obesity. *Am J Clin Nutr*. 55 (2, supp): 560s-566s, 1992.

Toskes P, Dawson W, Fitzgerald C. et al. Retinopathy following jejunoileal bypass surgery for obesity. *Clin Res Abstr.* 27:456a, 1978.

Tovey FI, Godfrey JE, Lewin MR. A gastrectomey population: 25-30 years on. *Postgrad Med J*. 66:450-6,1990.

Updegraff, TA, Neufeld NJ. Protein, iron and folate status of patients prior to and following surgery for morbid obesity. *J Am Diet Assoc*. 78 (2):135-140, 1981.

Wright HK, Tilson MD. Postoperative Disorders of the Gastrointestinal Tract. Grune & Stratton, New York, 1973.

Yale CE, Gohdes, PN, and Schilling, RF. Cobalamin absorption and hematologic status after two types of gastric surgery for obesity. *Amer J of Hema*. 42: 63-66, 1993.

Ziporin ZZ, Nunes WT, Powell RC, et al. Thiamine requirement in the adult human as measured by urinary excretion of thiamine metabolites. *J Nutr.* 85: 297-304, 1965.

Appendix

Gastric Bypass Vitamin Formulary

Supplement	**Daily Dose**
Vitamin A	20,000 IU
Vitamin B_1	150 mg
Vitamin B_2	150 mg
Niacinamide	150 mg
Vitamin B_5	150 mg
Vitamin B_6	150 mg
Folic Acid	1,000 mcg
Vitamin B_{12}	350 mcg
Intrinsic Factor	250 mg
Biotin	3,000 mcg
Vitamin C	500 mg
Vitamin E	200 IU
Iron	36 mg
Zinc	30 mg
Cooper	2 mg
Magnesium	150 mg
Potassium	40 mg