DEFICIT VITAMINICO/MINERALI DOPO CHIRURGIA BARIATRICA

LUIGI SCHIAVO

DIPARTIMENTO DI MEDICINA, CHIRURGIA E ODONTOIATRIA «*SCUOLA MEDICA SALERNITANA*»

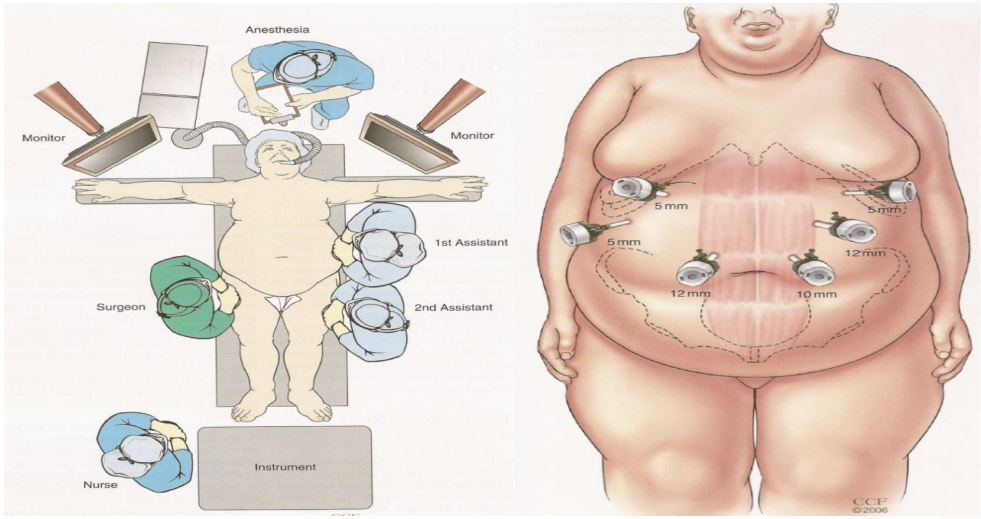
UNIVERSITÀ DEGLI STUDI DI SALERNO

Obesity Surgery
https://doi.org/10.1007/s11695-022-06332-1

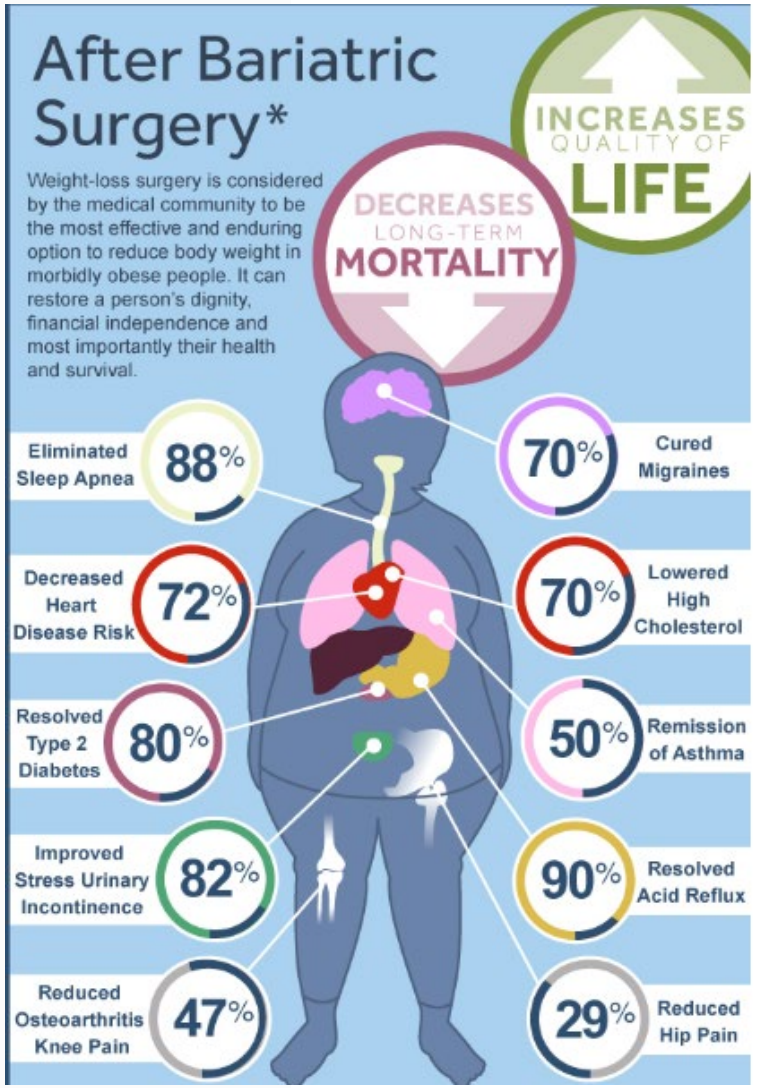
ORIGINAL CONTRIBUTIONS

2022 American Society of Metabolic and Bariatric Surgery (ASMBS) and International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) Indications for Metabolic and Bariatric Surgery

Dan Eisenberg[1] · Scott A. Shikora[2] · Edo Aarts[3] · Ali Aminian[4] · Luigi Angrisani[5] · Ricardo V. Cohen[6] · Maurizio de Luca[7] · Silvia L. Faria[8] · Kasey P.S. Goodpaster[4] · Ashraf Haddad[9] · Jacques M. Himpens[10] · Lilian Kow[11] · Marina Kurian[12] · Ken Loi[13] · Kamal Mahawar[14] · Abdelrahman Nimeri[15] · Mary O'Kane[16] · Pavlos K. Papasavas[17] · Jaime Ponce[18] · Janey S. A. Pratt[1,19] · Ann M. Rogers[20] · Kimberley E. Steele[21] · Michel Suter[22,23] · Shanu N. Kothari[24]



More effective therapy for the long-term treatment of obesity and related comorbidities



Obesity Surgery (2018) 28:3783–3794
https://doi.org/10.1007/s11695-018-3450-2

ORIGINAL CONTRIBUTIONS

IFSO Worldwide Survey 2016: Primary, Endoluminal, and Revisional Procedures

Luigi Angrisani[1] · A. Santonicola[2] · P. Iovino[2] · A. Vitiello[1] · K. Higa[3,4] · J. Himpens[5] · H. Buchwald[6] · N. Scopinaro[7]

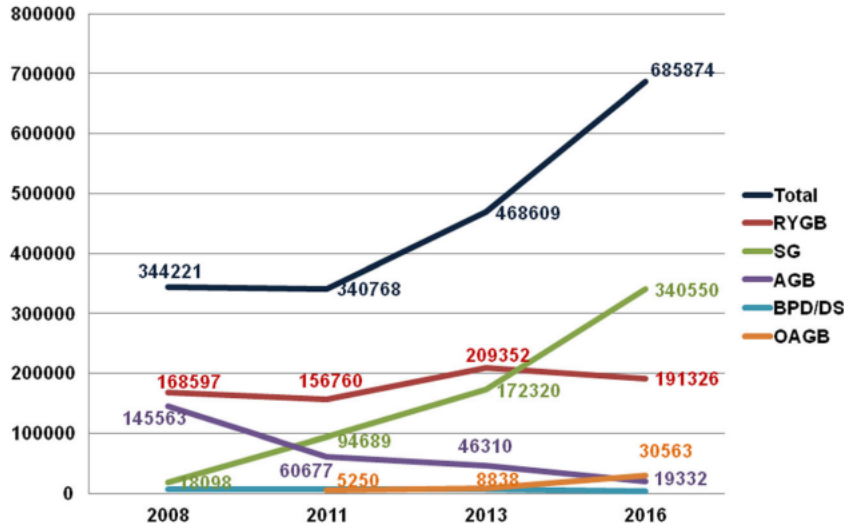


Fig. 2 Number of the main primary bariatric/metabolic surgical procedures from 2008 to 2016. AGB adjustable gastric banding, RYGB Roux-en-Y gastric bypass, SG sleeve gastrectomy, BPD-DS biliopancreatic diversion-duodenal switch, OAGB one-anastomosis gastric bypass

2018: RYGB and SG constitutes approximately 77% of the total bariatric surgeries performed in the World

Obesity Surgery (2021) 31:1755–1766
https://doi.org/10.1007/s11695-020-05160-5

REVIEW

Weight Regain and Insufficient Weight Loss After Bariatric Surgery: Definitions, Prevalence, Mechanisms, Predictors, Prevention and Management Strategies, and Knowledge Gaps—a Scoping Review

Walid El Ansari[1,2,3] · Wahiba Elhag[4]

2021: RYGB and SG constitutes approximately 95% of the total bariatric surgeries performed in the World

European Journal of Nutrition (2022) 61:55–67
https://doi.org/10.1007/s00394-021-02619-8

REVIEW

Micronutrients deficiences in patients after bariatric surgery

Amin Gasmi[1] · Geir Bjørklund[2] · Pavan Kumar Mujawdiya[3] · Yuliya Semenova[4,5] · Massimiliano Peana[6] · Alexandru Dosa[7] · Salva Piscopo[1,8] · Asma Gasmi Benahmed[9,10] · Daniel Ovidiu Costea[7]

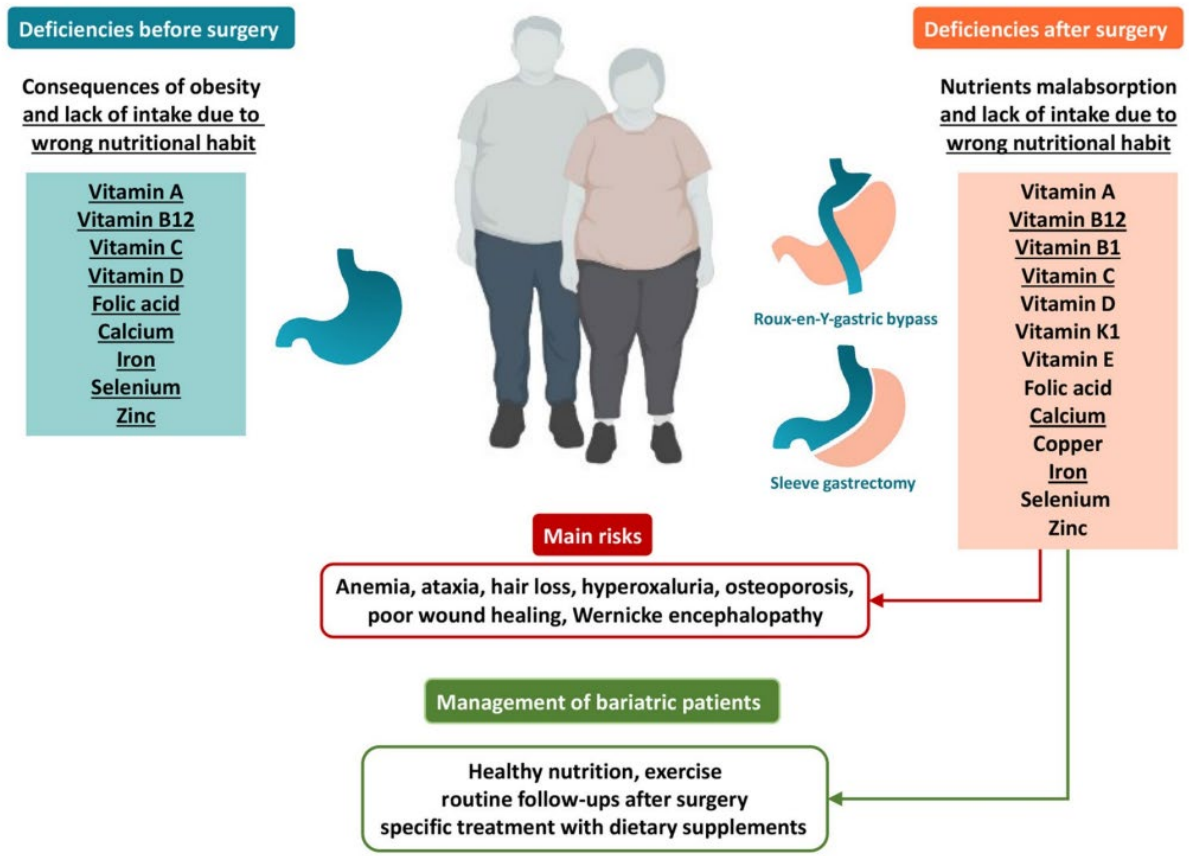


Fig. 1 Micronutrient deficiencies in obesity and after bariatric surgery, risks and management

Micronutrients Absorption in the GIT: Physiology

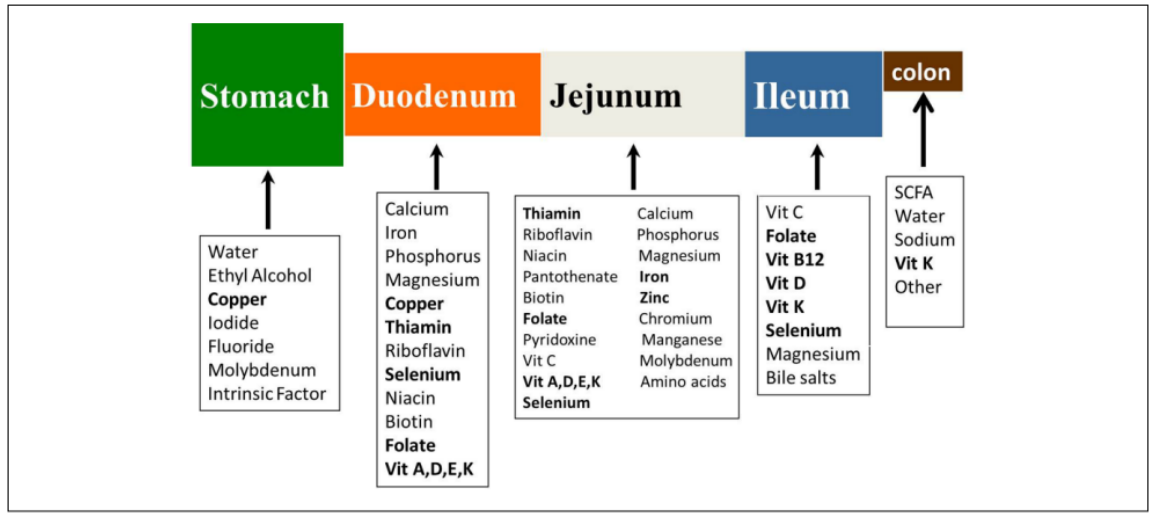


Figure 2. Anatomical depiction of micronutrient and macronutrient absorption. Bolded words indicate type and site of common micronutrient deficiencies. SCFA, short-chained fatty acid; Vit, vitamin.

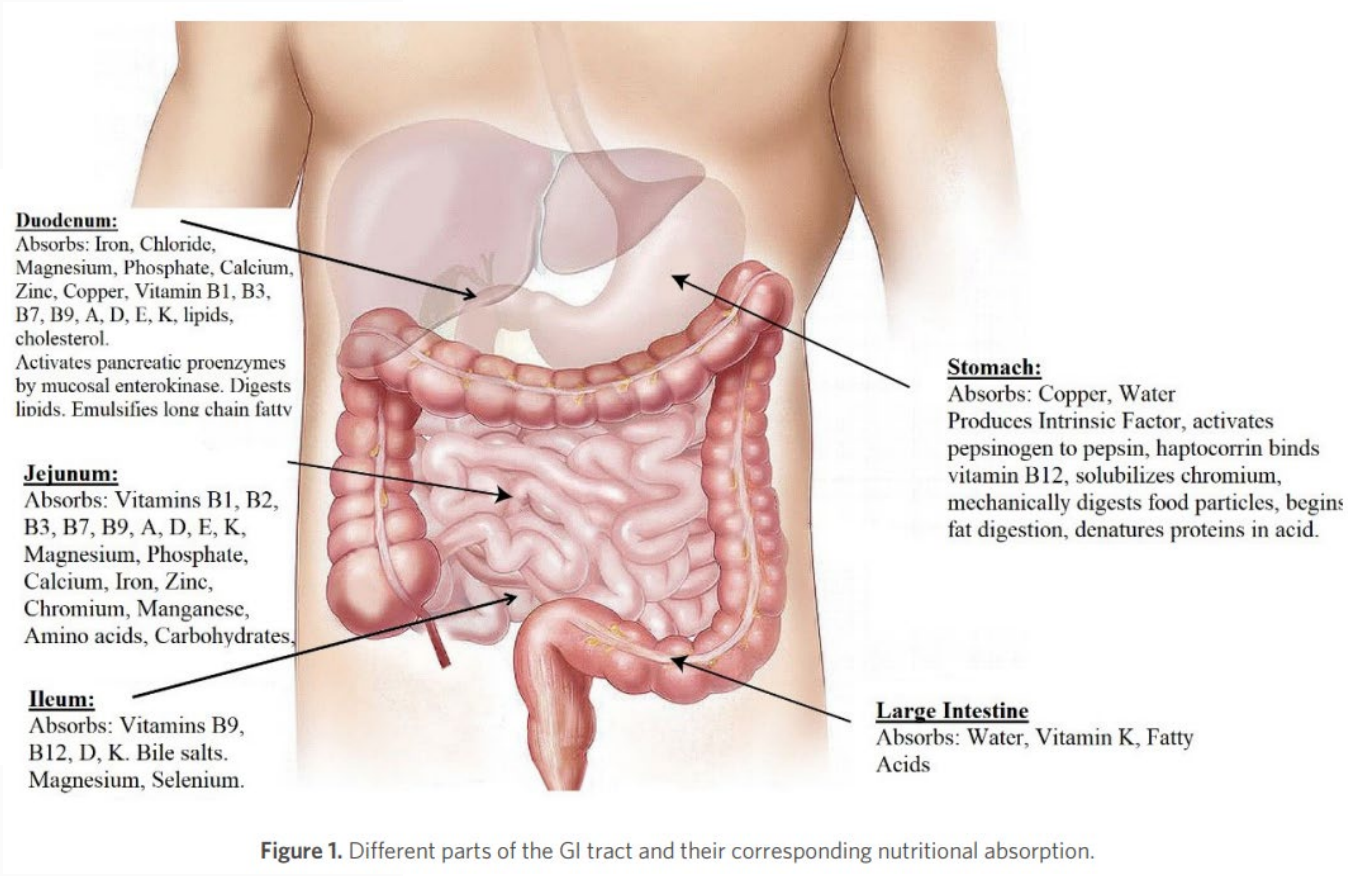
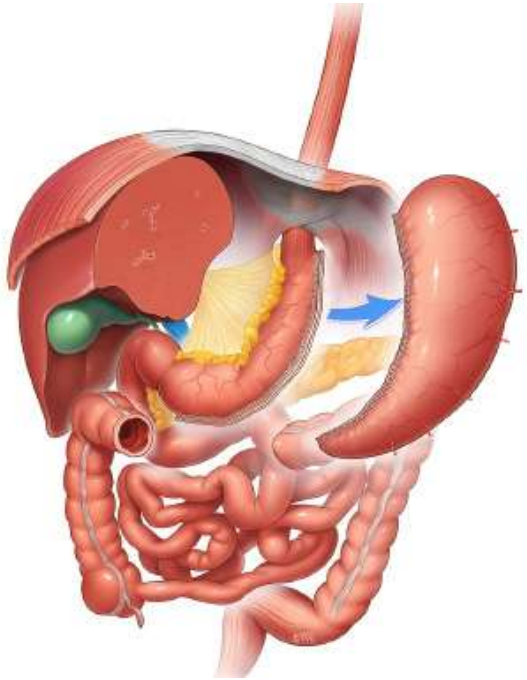


Figure 1. Different parts of the GI tract and their corresponding nutritional absorption.

Micronutrients deficiencies (MD) secondary to RESTRICTIVE or MALABSORPTIVE bariatric procedures are explained by different factors.

Sleeve Gastrectomy



OBES SURG (2011) 21:207–211
DOI 10.1007/s11695-010-0316-7

CLINICAL RESEARCH

The Gastric Sleeve: Losing Weight as Fast as Micronutrients?

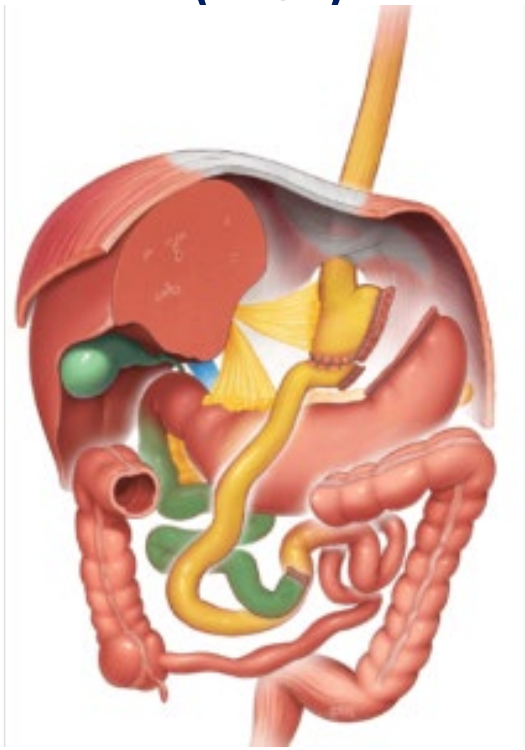
Edo O. Aarts · Ignace M. C. Janssen · Frits J. Berends

SG affects the VITAMINS status by changing:

- Gastrointestinal motility
- Gastric emptying
- Gastro-duodenal transit time
- HCL secretion
- IF secretion

Decreased intrinsic factor for Vitamin B12 absorption deficiencies is the most important deficiency.
Other VD include Vitamin B1, Vitamin D, and folate

Roux-en-Y gastric bypass (RYGB)



Obesity Facts

Research Article

Obes Facts 2021;14:197–204
DOI: 10.1159/000514847

Prevalence of Micronutrient Deficiency after Bariatric Surgery

Eva-Christina Krzizek[a, b] Johanna Maria Brix[a, b] Alexander Stöckl[a, b]
Verena Parzer[a, b] Bernhard Ludvik[a, b]

Basishvili *et al. Mini-invasive Surg* 2022;6:29
DOI: 10.20517/2574-1225.2021.130

Mini-invasive Surgery

Perspective

Open Access

Check for updates

Nutritional deficiencies following metabolic surgery

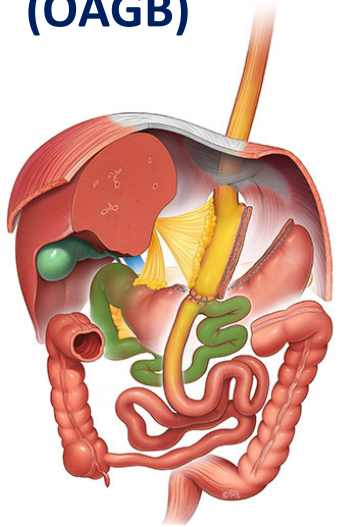
Givi Basishvili, Aurora Pryor

Roux-en-Y gastric bypass (RYGB) affects the vitamins and minerals status by:

- Changing the size of the stomach
- Changing the gastrointestinal transit time
- Bypassing the duodenum, thereby leading to a wider range of vitamins and minerals

The main cause of MD after RYGB is bypassing the main sites where the absorption of vitamins and minerals occurs

One Anastomosis gastric bypass (OAGB)



nutrients MDPI

Article

Nutritional Outcomes One Year after One Anastomosis Gastric Bypass Compared to Sleeve Gastrectomy

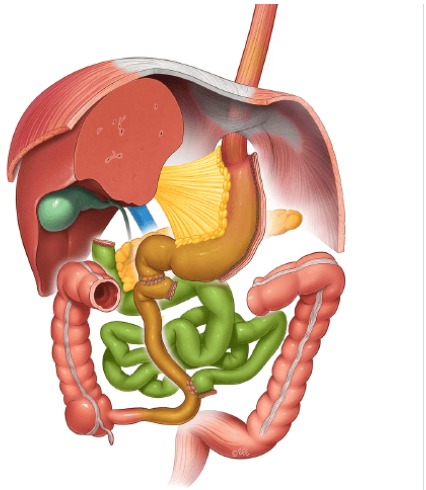
Naama Shirazi [1,2,*], Nahum Beglaibter [2], Ronit Grinbaum [2], Wiessam Abu Ahmad [3] and Anna Aronis [1]

One-Anastomosis Gastric Bypass (OAGB) affects the micronutrients status by:

- Changing the size of the stomach
- Bypassing part of the small bowel (duodenum and part of the jejunum).

The main cause of MD after OAGB is bypassing the main sites where the absorption of micronutrients occurs

Biliopancreatic diversion with duodenal switch (BPD-DS)



- Exclusion of the jejunum from the alimentary tract usually results in poor vitamin B12 absorption
- The short common channel of the BPD-DS deteriorates the absorption of fat-soluble vitamin (A, D, E, and K).
- The major mechanism contributing to fat-soluble vitamin deficiencies is delayed mixing of dietary fat with pancreatic enzymes and bile salts, creating fat malabsorption and maldigestion.

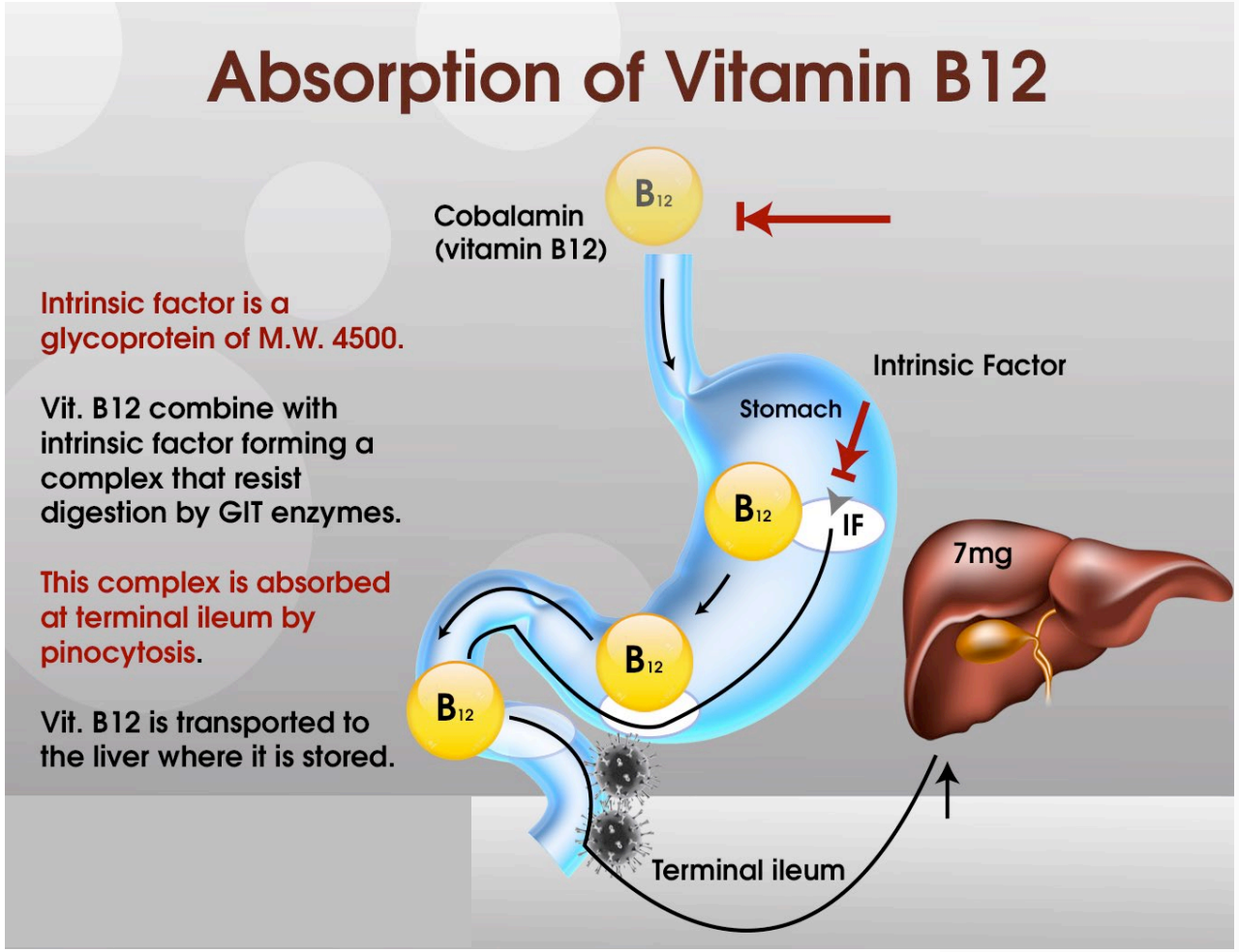
BPD-DS, due to creation of a short common channel, is a significant risk for long-term fat-soluble vitamin deficiencies. **Nett et al., demonstrated that despite supplementation, VD persisted 5 years after BPD-DS in 81% of their cohort, suggesting vitamins were not absorbed.**

OBES SURG (2016) 26:2469–2474

Vitamin B_{12} (Cobalamin)

deficiency is reported in 10–20% of SG patients

Intrinsic factor (IF), synthesized by the parietal cells of the stomach, plays a major role in cobalamin absorption



Changes in the architecture of the GIT secondary to gastric fundus resection result in decreased secretion of IF secretion.

Disrupted IF secretion is currently considered the main driver of the post-surgical B_{12} deficiency

Vitamin B_{12} (Cobalamin) deficiency is reported in 37–50% of gastric bypass patients

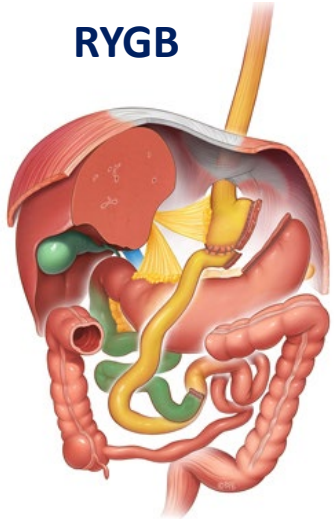
Citation: Clinical and Translational Gastroenterology (2017) 8, e212; doi:10.1038/ctg.2016.67

www.nature.com/ctg

Gastrointestinal Transcriptomic Response of Metabolic Vitamin B12 Pathways in Roux-en-Y Gastric Bypass

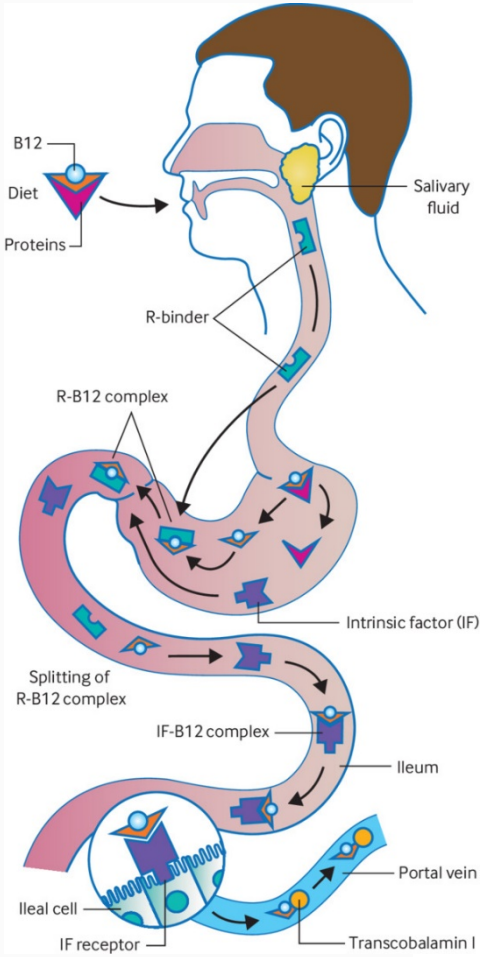
Priscila Sala, RD[1], Giliane Belarmino, RD[1], Raquel S. Torrinhas, PhD[1], Natasha M. Machado, RD[1], Danielle C. Fonseca, RD[1], Graziela R. Ravacci, PhD[1], Robson K. Ishida, MD[1], Ismael F. M.S. Guarda, MD[1], Eduardo G. de Moura, PhD[1], Paulo Sakai, PhD[1], Marco A. Santo, PhD[1], Ismael D. C.G. da Silva, PhD[2], Claudia C. A. Pereira, PhD[2], Angela F. Logullo, PhD[2], Steven Heymsfield, MD[3], Daniel Giannella-Neto, PhD[4] and Dan L. Waitzberg, PhD[1]

RYGB



The authors reported a **decrease in gastric production of transcobalamin 1 (TCN1) after RYGB that affects B_{12} intestinal transport.**

A 2017 small-scale study, involving 20 patients submitted to RYGB, proposed that, besides IF, other molecules involved in the vitamin B_{12} metabolism may be involved in the pathogenesis of its postoperative deficiency.



Using transcriptomic analysis, **increased B_{12}-receptor encoding genes' expression (CUBN) was detected at all levels of the GIT**, suggesting a potential genetic reprogramming of the intestinal tissue in order to compensate for insufficient B_{12} delivery.

Vitamin B_{12} (Cobalamin)

Clinical Nutrition 38 (2019) 906–911

Contents lists available at ScienceDirect

Clinical Nutrition

journal homepage: http://www.elsevier.com/locate/clnu

Original article

Early changes in vitamin B12 uptake and biomarker status following Roux-en-Y gastric bypass and sleeve gastrectomy

L.S. Kornerup [a, b, *], C.L. Hvas [c], C.B. Abild [d], B. Richelsen [d], E. Nexo [a]

B12 deficiency is associated with a triad of symptoms known as **Biermer's disease:**

- Megaloblastic anemia
- Gastrointestinal symptoms
- Neurologic symptoms

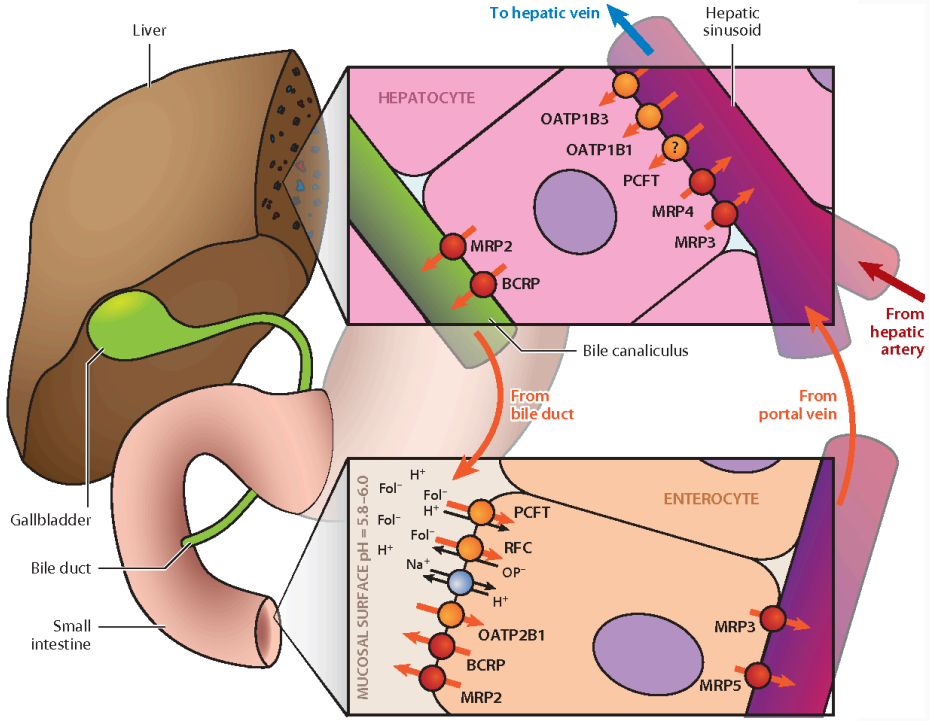
Administration of high doses of B12 is recommended to be initiated right after BS

350–500 mcg daily (sublingual/liquid) or 1000 mcg monthly (parenteral)

- **Obeid, R et al.** Vitamin B12 Intake From Animal Foods, Biomarkers, and Health Aspects. Front Nutr. 2019, 6, 93.
- **Parrott, J et al.** ASMBS Integrated Health Nutritional Guidelines for the Surgical Weight Loss Patient 2016 Update: Micronutrients. Surg. Obes. Relat. Dis. 2017, 13, 727–741.

Folate

Folate absorption occurs primarily in the upper small intestine (proximal jejunum)



Folate deficiency ranges between 9% and 39% following both malabsorptive and restrictive procedures

Folate deficiency can be elicited following BS due to:

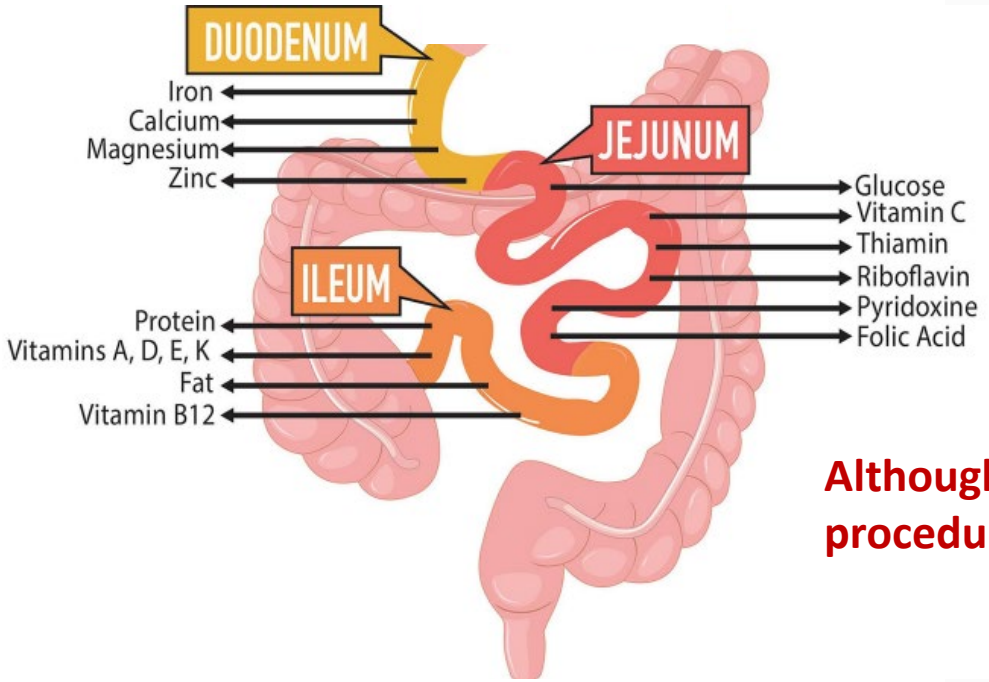
- the depletion of tissue stores as a result of inadequate dietary intake
- an impaired absorption due to hypochlorhydria
- an altered intestinal pH

Postoperative supplementation following RYGB with physiologic doses (400 mcg) suffices to prevent or correct the folate deficiency

Parrott, J et al. ASMBS Integrated Health Nutritional Guidelines for the Surgical Weight Loss Patient 2016 Update: Micronutrients. Surg. Obes. Relat. Dis. 2017, 13, 727–741.

Vitamin B_1 (Thiamine)

Thiamine absorption occurs primarily in the jejunum.



Since the body's pool of thiamine of about 30 g represents only 30 times the daily requirements, symptoms of deficiency rapidly develop when food intake fails to meet the nutritional needs. Body stores become depleted after only 20 days of inadequate oral intake and thiamine deficiency occurs faster than for any other vitamins.

Thiamine deficiency generally develops in bariatric patients within 6 months following surgery, mostly due to hyperemesis.

Intractable vomiting impairs absorption of thiamine and so deficiency can occur despite oral supplementation. Therefore, early diagnosis of thiamine deficiency is crucial to prevent permanent sequelae, such as Wernicke Encephalopathy (WE)

REVIEW

Wernicke Encephalopathy After Bariatric Surgery

A Systematic Review

Aasheim, Erlend Tuseth MD

Author Information

Annals of Surgery 248(5):p 714-720, November 2008.

ANNALS OF SURGERY

Out of 118 cases of WE following RYGB and VSG, almost 90% confirmed hyperemesis as a risk factor.

Although symptoms of thiamine deficiency are well described after malabsorptive procedures, its prevalence in bariatric patients cannot be precisely estimated

12 mg daily/50 mg dose from B-complex supplement/multivitamin twice daily

Parrott, J et al. ASMBS Integrated Health Nutritional Guidelines for the Surgical Weight Loss Patient 2016 Update: Micronutrients.
Surg. Obes. Relat. Dis. 2017, 13, 727–741

Vitamin D

Absorption of vitamin D occurs mostly in the jejunum and ileum through passive diffusion, a mechanism which rather requires the presence of bile salts

Bone Reports 8 (2018) 57–63

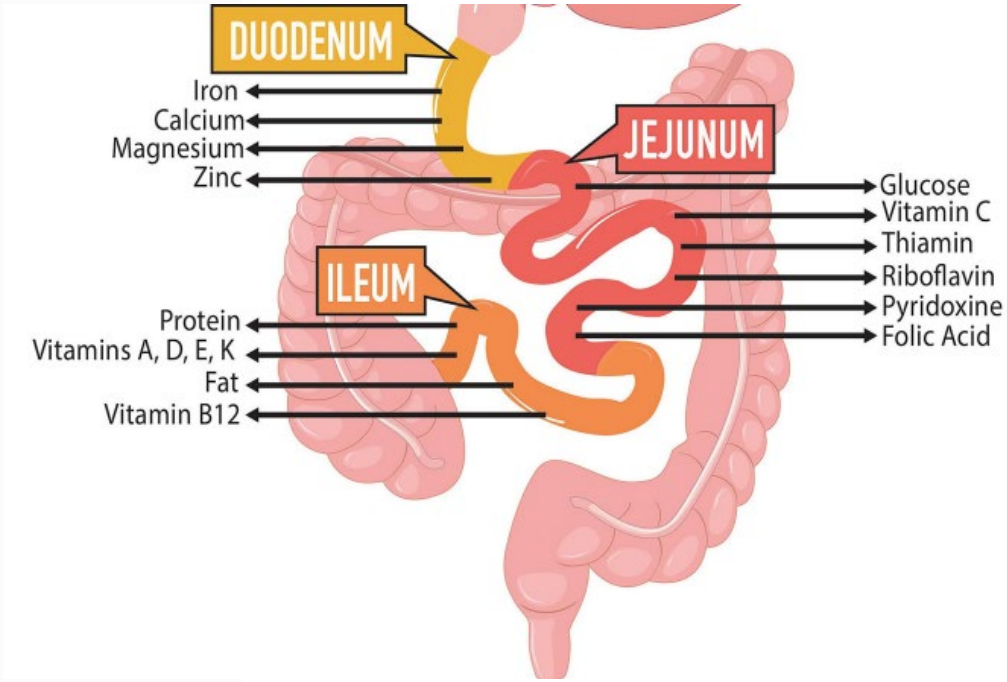
Contents lists available at ScienceDirect

Bone Reports

journal homepage: www.elsevier.com/locate/bonr

Thin bones: Vitamin D and calcium handling after bariatric surgery

Katrien Corbeels[a,*], Lieve Verlinden[a], Matthias Lannoo[a], Caroline Simoens[a,b], Christophe Matthys[a], Annemieke Verstuyf[a], Ann Meulemans[a], Geert Carmeliet[a], Bart Van der Schueren[a]



Following SG, vitamin D malabsorption might result from less exposure of the nutrients to the digestive mucosa.

In addition, the altered anatomy seen after RYGB has major consequences for the absorption of vitamin D as it is a fat-soluble hormone and hence needs biliary acids and digestive enzymes for uptake.

3000 IU daily until plasma concentration exceeds 30 ng/mol

Parrott, J et al. ASMBS Integrated Health Nutritional Guidelines for the Surgical Weight Loss Patient 2016 Update: Micronutrients. Surg. Obes. Relat. Dis. 2017, 13, 727–741.

Vitamin A, E, and K

The frequency of these nutritional deficiencies following BS is generally low.

nutrients

MDPI

Review

Bariatric Surgery in Obesity: Effects on Gut Microbiota and Micronutrient Status

Daniela Ciobârcă [1], Adriana Florinela Cătoi [2,*], Cătălin Copăescu [3], Doina Miere [1] and Gianina Crișan [4]

- Prevalence of vitamin A deficiency following RYGB ranges between 8% and 11%

Vitamin A deficiency is induced by malabsorption and severely diminished retinol and carotenoids' intake due to calorie restriction.

Moreover, a specific diet following weight loss surgery provides low levels of fat that limit vitamin A uptake.

Non-alcoholic steatohepatitis and cirrhosis, frequently observed in bariatric patients, might impede vitamin A storage and synthesis following surgery.

Vitamin E deficiency to be present in 8.7% of patients 1 year following RYGB
Reported vitamin E deficiency prevalence in bariatric literature after this type of surgical procedure varies between 0% and 22%

A recent systematic review concluded that, although rare following weight loss surgery, symptomatic vitamin K deficiency may occur in patients submitted to major malabsorptive procedures.

Vitamin A, 5000–10,000 IU/day
Vitamin E, 15 mg/day
Vitamin K, 90–120 ug/day

Parrott, J et al. ASMBS Integrated Health Nutritional Guidelines for the Surgical Weight Loss Patient 2016 Update: Micronutrients. Surg. Obes. Relat. Dis. 2017, 13, 727–741.

Invited Review

aspen | LEADING THE SCIENCE AND PRACTICE OF CLINICAL NUTRITION
American Society for Parenteral and Enteral Nutrition

Nutrition in Clinical Practice
Volume 32 Number 4
August 2017 471–480

DOI: 10.1177/0884533617712226
journals.sagepub.com/home/ncp
SAGE

Micronutrient Deficiencies After Bariatric Surgery: An Emphasis on Vitamins and Trace Minerals

Jayshil J. Patel, MD[1]; Manpreet S. Mundi, MD[2]; Ryan T. Hurt, MD, PhD[3]; Bruce Wolfe, MD[4]; and Robert G. Martindale, MD, PhD[5]

Table 3. Fat-Soluble Vitamin Deficiencies at 1, 2, 3, and 4 Years After Biliopancreatic Diversion With Duodenal Switch.

Disorder	Year 1, %	Year 2, %	Year 3, %	Year 4, %
Low vitamin A	52	58	70	69
Low vitamin D	57	55	46	63
Low vitamin K	14	21	13	68

Data from Slater GH, Ren CJ, Siegel N, et al. Serum fat-soluble vitamin deficiency and abnormal calcium metabolism after malabsorptive bariatric surgery. *J Gastrointest Surg*. 2004;8(1):48-55. doi:10.1016/j.gassur.2003.09.020.

Table 4. Common Water-Soluble Vitamin and Trace Mineral Deficiencies Before and After Bariatric Surgery.

Nutrient	Preoperative, %	SG, %	LAGB, %	RYBG, %	BPD-DS %
Folate	3–4	22	10	0–12	5
Thiamin	0–29	NS	NS	12–18	NS
Vitamin B_{12}	3–8	18	0–19	33–58	22
Vitamin C	43	NS	NS	10–50	NS
Iron	7–37	14	0–32	5–42	21–100
Zinc	14–50	34	NS	37	10–50
Copper	NS	NS	NS	10	70

BPD-DS, biliopancreatic diversion with duodenal switch; LAGB, laparoscopic gastric band; NS, not significant; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy.

Deficiencies of minerals and trace elements

Like the deficiency of vitamins, bariatric surgery also leads to the deficiency of several minerals and trace elements such as iron, zinc, copper, calcium, and selenium.

European Journal of Nutrition (2022) 61:55–67
https://doi.org/10.1007/s00394-021-02619-8

REVIEW

Check for updates

Micronutrients deficiences in patients after bariatric surgery

Amin Gasmi[1] · Geir Bjørklund[2] · Pavan Kumar Mujawdiya[3] · Yuliya Semenova[4,5] · Massimiliano Peana[6] · Alexandru Dosa[7] · Salva Piscopo[1,8] · Asma Gasmi Benahmed[9,10] · Daniel Ovidiu Costea[7]

IRON

Iron absorption sites are mainly located in the duodenum and proximal jejunum, and bypassing them severely reduces iron absorption

Iron deficiency is one of the most common trace element deficiencies and affects around 33% of patients undergoing bariatric procedures.

Moreover, dietary changes such as:

- lower intake of meat
- Lower intake of iron-fortified dairy products post-surgery may aggravate the iron deficiency

Prospective studies based on iron supplementation strategies are urgently needed

OBES SURG (2017) 27:2905–2911
DOI 10.1007/s11695-017-2705-7

ORIGINAL CONTRIBUTIONS

Hypocalcemia After Bariatric Surgery: Prevalence and Associated Risk Factors

Meera Shah[1] · Anu Sharma[1] · Robert A. Wermers[1] · Kurt A. Kennel[1] · Todd A. Kellogg[2] · Manpreet S. Mundi[1]

CALCIUM

Iron absorption sites are mainly located in the duodenum and proximal jejunum, and bypassing them severely reduces iron absorption

In a recent retrospective study involving patients that undergo bariatric surgery from 2008 to 2014, it was shown that, in about 1000 patients, the prevalence of hypocalcemia after bariatric surgery was 3.6%. In particular, the prevalence was 10% in the BPD-DS group, 9.3% in the SG group, and 1.9% in the RYGB group, respectively

It is important to highlight that vitamin D deficiency can further exacerbate calcium deficiency because vitamin D is required for normal calcium absorption in the intestine and plays a central role in its homeostasis

A strategy based on adequate calcium and vitamin D supplementation should be carefully monitored, particularly in patients at high risk for developing symptomatic hypocalcemia in case of pre-existing renal insufficiency and vitamin D deficiency.

European Journal of Nutrition (2022) 61:55–67
https://doi.org/10.1007/s00394-021-02619-8

REVIEW

Check for updates

Micronutrients deficiences in patients after bariatric surgery

Amin Gasmi[1] · Geir Bjørklund[2] · Pavan Kumar Mujawdiya[3] · Yuliya Semenova[4,5] · Massimiliano Peana[6] · Alexandru Dosa[7] · Salva Piscopo[1,8] · Asma Gasmi Benahmed[9,10] · Daniel Ovidiu Costea[7]

ZINC

Zinc is absorbed in the proximal intestine, and bypassing the absorption route leads to poor absorption.

It is important to note that 42–65% of patients develop zinc deficiency within 6–18 months post-surgery, indicating a direct and strong association between them

SELENIUM

Selenium is primarily absorbed in the duodenum and proximal jejunum and its deficiency **has been evidenced in postoperative bariatric surgery (RYGB and SG) with a prevalence from 11 to 46%.**

COPPER

Studies have shown that copper deficiency affects 10–15% of individuals after RYGB surgery.
The other cause of copper deficiency is inadequate intake of copper from the diet

European Journal of Nutrition (2022) 61:55–67
https://doi.org/10.1007/s00394-021-02619-8

REVIEW

Micronutrients deficiences in patients after bariatric surgery

Amin Gasmi[1] · Geir Bjørklund[2] · Pavan Kumar Mujawdiya[3] · Yuliya Semenova[4,5] · Massimiliano Peana[6] · Alexandru Dosa[7] · Salva Piscopo[1,8] · Asma Gasmi Benahmed[9,10] · Daniel Ovidiu Costea[7]

Table 1 Deficiencies of vitamins and trace elements after bariatric surgery and the associated clinical manifestations and diseases

Deficiency	Clinical manifestations—diseases
Vitamins	
Vitamin B12	Lost of body coordination, numbness, neurological complications, memory impairment, macrocytic anemia, leucopenia, infertility
Vitamin B1	Wernicke–Korsakoff syndrome, constipation, nausea, fatigue, anorexia, numbness, weakness
Vitamin A	Insomnia, acne, hyperkeratosis, night blindness, fatigue, immune impairment, dry hair
Vitamin K	Blood clotting disorders, osteoporosis
Vitamin C	Fatigue, delayed wound healing, depression, scurvy
Minerals	
Iron	Anemia, immunodeficiency, fatigue, weakness, pale skin, headaches, dizziness, heart palpitations, shortness of breath, cold extremities, hair loss, gastrointestinal complaints
Calcium	Osteoporosis, tooth decay, depression, heart problem, weak nails, dermatitis, hypertension, muscle spams, sleeplessness
Zinc	Slow healing, hair loss, acrodermatitis, anxiety, depression, hormone disturbance, poor concentration, immune dysfunction
Copper	Fatigue, weakness, pallor, join pains, muscle pain, numbness, tingling, osteoporosis, anemia, frequent illness, skin inflammation, cold sensitivity
Selenium	Immune system dysfunction, vulnerability to infection, fatigue, hair loss, liver dysfunction, thyroid dysfunction, reproductive disorders

CONCLUSIONS

European Journal of Nutrition (2022) 61:55–67
https://doi.org/10.1007/s00394-021-02619-8

REVIEW

Check for updates

Micronutrients deficiences in patients after bariatric surgery

Amin Gasmi[1] · Geir Bjørklund[2] · Pavan Kumar Mujawdiya[3] · Yuliya Semenova[4,5] · Massimiliano Peana[6] · Alexandru Dosa[7] · Salva Piscopo[1,8] · Asma Gasmi Benahmed[9,10] · Daniel Ovidiu Costea[7]

Main Factors responsible for MD after BS

1. Preoperative MD not identified and corrected before BS
2. The type of the surgery
3. Postsurgical complications such as nausea and vomiting, and food intolerance
4. Inadequate supplementation
5. Low compliance to dietary and alcohol abuse after BS (4.2%)
6. Low compliance to supplement recommendations

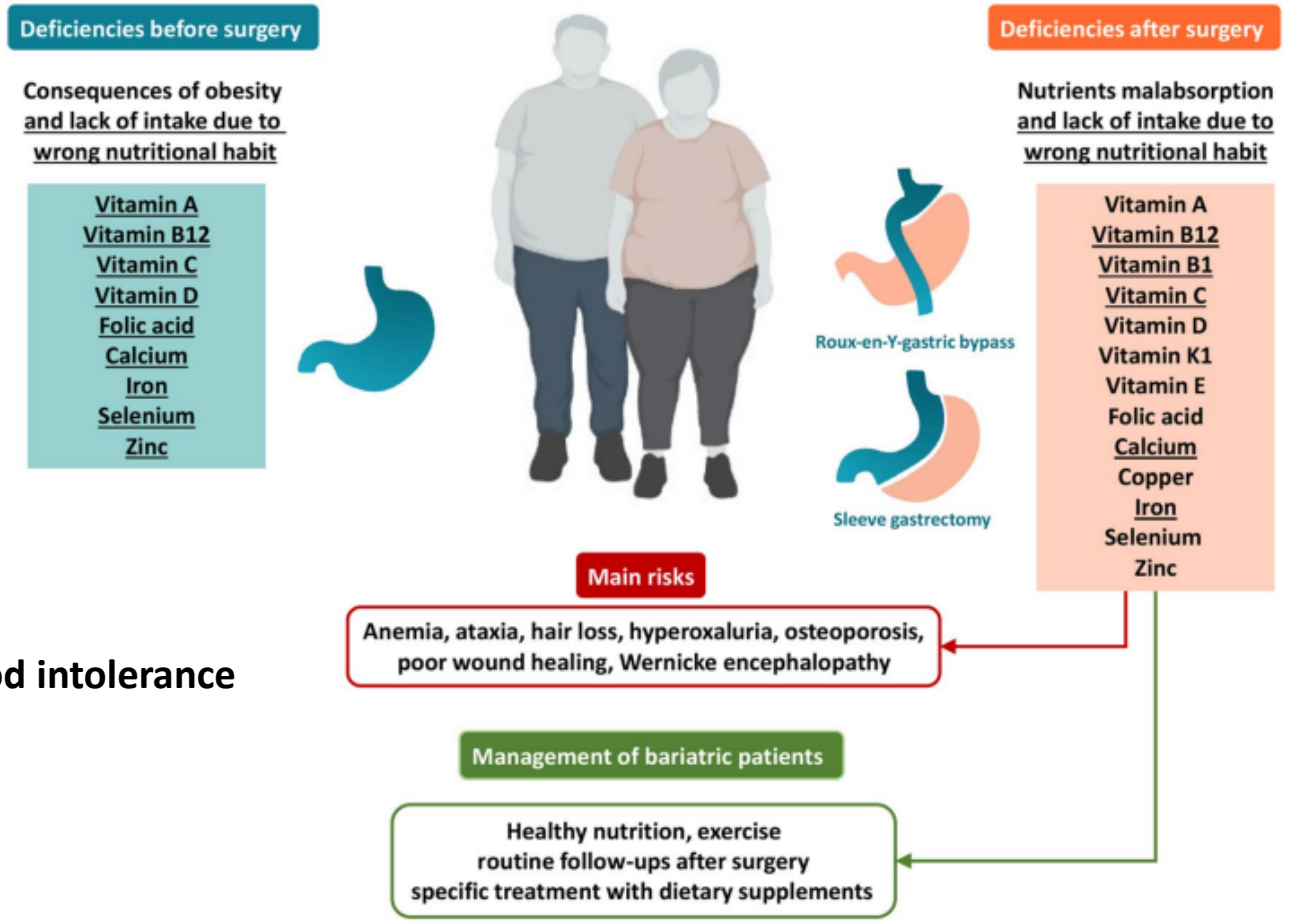


Fig. 1 Micronutrient deficiencies in obesity and after bariatric surgery, risks and management

TAKE HOME MESSAGE

- Patient- and surgery related variables contribute to MD after BS
- After BS, a careful monitoring and treatment of MD by an experienced multidisciplinary team is crucial
- Programmed screening are crucial to identify MD earlier and allows for intervention before development of clinical symptoms

Grazie

lschiavo@unisa.it