Journal of Visceral Surgery (2020) xxx, xxx—xxx

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Recommendations for nutritional care after bariatric surgery: Recommendations for best practice and SOFFCO-MM/AFERO/SFNCM/expert consensus☆

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Summary Nutritional care after bariatric surgery is an issue of major importance, especially insofar as risk of deficiency has been extensively described in the literature. Subsequent to the deliberations carried out by a multidisciplinary working group, we are proposing a series of recommendations elaborated using the Delphi-HAS (official French health authority) method, which facilitates the drawing up of best practice and consensus recommendations based on the data of the literature and on expert opinion. The recommendations in this paper pertain to dietary management and physical activity, multivitamin and trace element supplementation and the prevention and treatment of specific deficiencies in vitamins B1, B9, B12, D and calcium, iron, zinc, vitamins A, E and K, dumping syndrome and reactive hypoglycemia.

DOI de l'article original : https://doi.org/10.1016/j.jchirv.2020.10.002.
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https://doi.org/10.1016/j.jviscsurg.2020.10.013

Method

This recommendation has been elaborated using a Delphi method drawn up by the official French health authority (HAS) and designated as ''Recommendations by formalized consensus'', which is at once:
- a method leading to establishment of recommendations for best practice and;
- a method aimed at achieving consensus [1].

A national panel of practitioners in public and private bariatric and post-bariatric care structures including several physician nutritionists and bariatric surgeons possessing both the requisite skills and wide-ranging experience was selected by the steering committee. The relevance and importance of each proposition were assessed using a discrete numerical scale graduated from 1 to 9; while a rating of 1 signified that the proposition was deemed ''totally inappropriate'', a rating of 9 meant ''totally appropriate'', and a rating of 5 corresponded to indecision. Following each round, the experts' responses were analyzed, incorporating the remarks put forward with regard to each proposition, before submitting them for the consideration in the following round. Following distribution of the ratings, the results of the analyses were presented in the form of medians. They were divided into three assessment classes: namely appropriate, inappropriate and uncertain, with two degrees of agreement between experts: namely pronounced or relative agreement for the first two classes, and indecision or absence of consensus for the last class. The validated version was submitted for review by practitioners in a plenary session. After two rounds of ratings, all of the propositions except for #22 (appropriate and relative agreement) were deemed appropriate, with pronounced agreement (details of the DELPHI method available online in the long version of the recommendations — Appendix 1).

Which lacks or deficiencies should be targeted prior to bariatric surgery?

A nutritional and vitamin-based assessment (albumin, hemoglobin, ferritin assay and transferrin saturation coefficient, serum calcium, 25-hydoxy vitamin D, vitamins B1, B9, B12) and correction of possible nutritional deficiencies are recommended by the HAS prior to an operation, whatever the type of planned surgery [2].

The prevalence of micronutrient deficiency may be markedly high in an obese patient or prior to bariatric surgery. The most frequently reported deficiencies have involved vitamins B1, B9, A, C and D and B12 [3—5].

Future research

The future research will be the:
- validation of the markers of micronutrient deficiency in an obese person (distinction between metabolic adaptation and deficiency or lack);
- physiopathological studies.

What dietary approach should be applied subsequent to bariatric surgery?

Following bariatric surgery (whatever the type of operation), management by a dietitian-nutritionist is indispensable.

Following bariatric surgery (whatever the type of operation), long-term protein intake should be encouraged, in association with physical activity, in view of limiting muscle atrophy and loss of function, as well as malnutrition.

Recommended protein intake consists in a minimum of 60 g/day and, ideally, at least 1.1 g of proteins/ideal weight in kg/day.

Notwithstanding tailored dietetic advice, in some cases the objective of 60 g of proteins a day fails to be reached, and oral or proteinaceous nutritional supplements may be useful.

Following bariatric surgery, management by a dietitian-nutritionist appears indispensable [6]. Data in the literature are scarce. A pilot study [7] nonetheless illustrates the interest of this type of eating habit modification management, which can have substantial influence on long-term weight loss maintenance. Attentiveness to rheology (how one's food looks and feels), avoidance of vomiting, fractionated nutrition and dietary advice in view of precluding the dumping syndrome are useful during the first weeks following an operation.

Future research

The future research will be:
- protein needs in the obese patient;
- clinical effects of protein supplementation and type of proteins during the dynamic weight loss phase

What are the recommendations for physical activity after bariatric surgery?

Following bariatric surgery (whatever the type of operation), regular tailored physical activity should be encouraged, subsequent to the surgeon's agreement and, if possible, that of a physical exercise professional (Adapted physical activity — APA — instructor, kinesitherapist).

The objective is to target endurance activity, adapted to the age and capacities of the patient, lasting at least 30 minutes, 5 days a week, and associated with muscle reinforcement sessions 2 or 3 times a week.

Early mobilization (walking...) is to be encouraged as of the 1st postoperative day (in cases of laparoscopic approach) subsequent to the surgeon's agreement.

These recommendations are in conformity with those of the WHO and the French PNNS on physical activity and health, recommendations updated in 2016 by the ANSES network with regard to the general population [8—11] and by

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the Haute Autorité de santé (HAS) recommendations for the improved post-surgical rehabilitation program (RAAC) [10] and for the prevention of venous thromboembolic disease (European recommendations) [12].

Future research

Elaboration of tailored physical activity retraining programs prior to surgery and during the dynamic ''slimming down'' or weight loss phase.

Which supplementary multivitamins and trace elements should be prescribed?

During the ''slimming down'' phase, whatever the type of operation, multivitamin and trace element supplements are strongly recommended.

Following Roux-en-Y and malabsorptive (bilio-pancreatic deviation surgery) and in the absence of long-term data, multivitamin and trace element supplements are recommended throughout the rest of the patient's life.

The proposition underpinning these recommendations is premised on a distinction between slimming down and the subsequent phase. During the initial weight loss phase (the first year), micronutrient intakes do not suffice to cover the patient's needs. Whatever the type of operation, they are inferior to 50% of the French nutritional reference (RNP) requirements [13—20]. During this phase, the addition of multivitamins and trace elements provides partial coverage of the patient's needs [21]. Even without long-term postoperative data, this proposition is valid with regard to sleeve gastrectomy [22].

In the long-term, continued supplementation can be justified according to calorie intake level and degree of malabsorption, which vary according to type of operation, and to the results of systematically performed bioassays [5,15—17,20]. In addition to the impact of vitamin supplementation on the number of deficiencies, it has been shown that some postoperative deficiencies are associated not only with short-term preoperative deficiencies [18,23], but also with those persisting more than two years after sleeve gastrectomy [24,25].

Future research

The future research will be:

- early identification of patients at high risk of deficiency (predictive factors for deficiency risk);
- elaboration of appropriate screening and assessment tools according to the results of present and future interventional trials;
- anticipation of micronutrient needs according to type of intervention and the specificities of individual patients.

How can specific vitamin and trace element deficiencies be prevented and treated?

Vitamin B1

Following bariatric surgery, even in the absence of any clinical sign or pathological bioassay, a patient presenting over several days with food intolerance and repeated digestive disorders (vomiting...) requires thiamine (vitamin B1) supplementation, whatever the type of surgery.

Following bariatric surgery, a patient presenting with digestive disorders (vomiting, diarrhea, food intolerance) associated with specific or non-specific neurological or psychiatric signs, must systematically be treated for Gayet-Wernicke encephalopathy (also known as Gayet-Wernicke syndrome) even while other possible etiologies are being explored.

In the event of suspected Gayet-Wernicke encephalopathy, it is recommended to provide vitamin B1 supplementation by parenteral route (500 mg 3×/d) for 3 days, and that it be associated first with magnesium supplementation (magnesium sulfate at 6 to 8 mmol of magnesium-element over a period of 24 hours), and then at 250 mg/d by oral or parenteral route for at least 5 days, without waiting for the biological result of the thiamine assay, which may be normal.

Prevalence of low vitamin B1 concentration following bariatric surgery ranges from 1 to 49% according to type of operation and duration of monitoring [26—31]. After Roux-en-Y gastric bypass, 6% prevalence has been found during the 4 years of follow-up [32]. After sleeve gastrectomy, low concentration has been found in 0.5% of patients at 6 months and in 6% after 2 years [27,33]. Also after sleeve gastrectomy, another study reported a high risk of vitamin B1 insufficiency (26%) during the first postoperative year, with high initial BMI, vomiting and Afro-American ethnicity appearing as independent risk factors [27].

Prevalence of Gayet-Wernicke encephalopathy approximates 20 cases/10,000 procedures, with malabsorptive surgery (bilio-pancreatic deviation) predominating [26]; were autopsy series to be included, prevalence would be higher (0.6 to 2%) [34].

Given the non-toxicity, even at high doses, of vitamin B1, and taking into account the imperfection of plasma assay, this vitamin may be used in prevention and empirical treatment of all patients suspected of deficiencies, whatever may be the assay results. Indeed, Gayet-Wernicke prevention by means of vitamin B1 supplementation must be systematic in any patient presenting with digestive disorders, vomiting or prolonged diarrhea, particularly after digestive surgery, and also in any patient at risk of refeeding syndrome (RFS). As

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a rule, a dose of 100 mg is prescribed, by perfusion or by intramuscular injection when the patient vomits, or by oral route if he does not [35]. That such said, there exists no risk of hypervitaminosis, and the doses habitually prescribed in western countries are markedly higher than 100 mg [36—40].

In the event of suggestive neurological signs, treatment by parenteral route must get underway immediately [26]. Relay by the oral route is generally possible. During this phase, carbohydrate intake is classically limited. In a ''wet'' thiamine deficiency (beriberi), treatment by vitamin B1 at a dose of 50 to 100 mg/day by parenteral route improves cardiac function; it is relayed by oral route (10 mg/d) [35].

Magnesium is a cofactor for transketolase and thiamine pyrophosphokinase. Magnesium deficiency is a classical cause of resistance to vitamin B1 supplementation during deficiency syndromes [41]. Magnesium is consequently systematically associated with vitamin B1 supplementation.

Vitamin B12

Following Roux-en-Y bypass, high prevalence of vitamin B12 deficiency and the number of patients lost to follow-up justify systematic supplementation and systematic biological monitoring 3 times during the first year and subsequently once or twice a year, for the rest of the patient's life in the absence of long-term data.

Following sleeve gastrectomy, prevalence of vitamin B12 deficiency may be high, thereby justifying systematic biological monitoring once or twice a year in the long-term. In cases of deficiency, oral supplementation should get underway and be pursued for the rest of the patient's life, in the absence of long-term data.

Following bilio-pancreatic deviation, with or without duodenal switch, high prevalence of vitamin B12 deficiency justifies lifelong systematic supplementation and systematic biological monitoring 3 times during the first year and subsequently once or twice a year, for the rest of the patient's life in the absence of long-term data.

Systematic vitamin B12 supplementation is administered by oral route at a daily dose of 250 μg/d to 350 μg/d or a weekly dose of 1 or 2 1000 μg vials of vitamin B12. The alternative is to prescribe 1000 μg supplementation by intramuscular injection every 1 to 3 months, or else 3000 μg every 6 months, in the event of non-compliance or ineffectiveness by oral route. In case of deficiency, a dose of 1000 μg/d for 2 weeks by oral route can successfully alleviate the insufficiency.

While vitamin B12 deficiency is extremely frequent following Roux-en-Y bypass surgery, it is by no means rare after restrictive surgery.

Following gastric bypass surgery, systematic supplementation is justified by the following arguments [15,32,42—52]:

- prevalence of deficiency or insufficiency following gastric bypass is markedly high, as is the case after other malabsorptive surgeries;
- prevalence of patients lost to follow-up is extremely high, and the risk of non-screening for the deficiency is correspondingly elevated. In this context, it seems unreasonable to await the exhaustion of hepatic reserves;
- long-term vitamin B12 deficiency can have severe repercussions, particularly from a neuro-psychiatric standpoint (neuropathy, accelerated cognitive decline...);
- even at exceedingly high doses, the vitamin is not known to be in any way toxic;
- the low cost and high effectiveness of vitamin B12 supplementation by the oral route have been amply demonstrated.

Following sleeve gastrectomy, the main recommendations pertain to systematic supplementation adjusted to vitamin B12 serum levels (American recommendations) [53,54]. An alternative strategy, recommended by the majority of French experts, consists in supplementation in cases of patent deficiency. The data in the literature do not allow for adjudication [16,22,25,44,45,55—64].

After bilio-pancreatic bypass, only one study evaluated the long-term (more than 10 years) prevalence of deficiency subsequent to this operation [65]. In this series, 23.9% of the patients underwent intramuscular injection of vitamin B12 supplementation; among those without recent supplementation, 2.7% presented insufficiencies.

Oral supplementation was thereby shown to be possible when vitamin B12 was provided in a crystal form and at a high dose [66], provided that 1000 to 2000 μg/d were administered during the first weeks, and subsequently weekly and monthly [67]. Pharmacokinetic studies have shown that approximately 1 to 5% of a dose exceeding 25 μg is absorbed passively, that is to say 10 μg for a dose of 1000 μg, (advised nutritional intake = 2.4 μg/d) [68]. Following gastric bypass surgery, doses range from 350 μg/d [69] to 1000 μg/week. At times, the dose can be doubled, and intermuscular injection remains exceptional [47]. Possible non-compliance and long-term loss to follow-up remain the principal obstacles, and supplementation strategy must be taken into close account [70]. The parenteral route can be justified in the event of non-compliance or ineffectiveness of the oral route (microbial pullulation).

Future research

The future research will be:

- factors and tests predictive of deficiency risk;
- prevalence of vitamin B12 deficiency after sleeve gastrectomy, in the absence of supplementation;
- supplementation strategy following sleeve gastrectomy so as to avoid deficiency risk, at minimum cost.

Vitamin D and calcium

Following Roux-en-Y bypass or sleeve gastrectomy, systematic vitamin D supplementation is recommended.

Following Roux-en-Y bypass or sleeve gastrectomy, systematic vitamin D supplementation by oral route is recommended either daily (at least 800 IU of vitamin D/d), or at a dose of 100,000 IU every month, or less frequently according to the dosage of 25-OH vitamin D (objective > 30 ng/mL).

Following Roux-en-Y bypass or sleeve gastrectomy, calcium supplementation must be associated with vitamin D when oral intake is insufficient and/or in the event of increased parathormone or decreased calcinuria. One should begin with a calcium dose of 1000 mg taken twice a day according to food intake.

After malabsorptive surgery (bilio-pancreatic deviation with or without duodenal switch), systematic long-term vitamin D supplementation is called for.

After malabsorptive surgery (bilio-pancreatic deviation with or without duodenal switch), vitamin D supplementation is carried out by the oral route, at a dose of 50,000 IU, 1 or 2 times a week, or else by intramuscular injection (200,000 IU/month) and associated with 1—1.5 g of calcium a day.

After Roux-en-Y bypass, vertical sleeve gastrectomy or malabsorptive surgery (bilio-pancreatic deviation with or without duodenal switch), calcium citrate is to be preferred to the other forms of calcium.

While in 90% of cases Vitamin D insufficiency pre-exists surgical intervention [71], more often than not it is aggravated after the operation. Accelerated osteoporosis is one of the long-term complications to be feared, especially insofar as it entails increased risk of fracture [72]. And given the major risk of loss to follow-up, systematic supplementation is recommended following Roux-en-Y gastric bypass [72—84], sleeve gastrectomy [15,21,56,57,85—88] and bilio-pancreatic deviation [65,72].

It seems reasonable to provide calcium supplementation only for patients with deficient intake and increased PTH or low urine calcium following Roux-en-Y gastric bypass, sleeve gastrectomy [56], and a large proportion of patients lost to follow-up (from 66 to 90%) [22,56,59,61,62]. Following bilio-pancreatic deviation surgery, the risk of accelerated osteoporosis and the risk of fracture are major. [65,72,89,90].

Numerous studies [64,76,91] have shown that in the absence of gastric acidity, calcium citrate was optimally absorbed.

Future research

Strategy for risk fracture prevention.

Iron deficiency

Iron malabsorption in obese subjects has been confirmed in different studies [92—95]. Increased iron absorption by vitamin C remains present but shows imbalance according to corpulence (28% in an obese patient vs. 56% in a person of standard weight) [94,95].

Iron deficiency is highly frequent following bariatric surgery. It is associated with insufficient intake and a degree of malabsorption that varies according to type of operation. The elevated prevalence of iron deficiency tends to fluctuate from one study to the next (about one third of patients after gastroplasty [96] and more than 50% following Roux-en-Y bypass) [42,46,97]. In any case, it is the principal cause of anemia subsequent to bariatric surgery [43]. Analysis in the literature is biased by the fact that supplementation modalities, multivitamin composition and patient compliance are not taken into account.

Whatever the type of operation, risk of iron deficiency after bariatric surgery is markedly high, particularly in menstruating women, notwithstanding intake of multivitamin and trace element supplements. Risk of iron deficiency amply justifies systematic screening, 3 times during the first year, and subsequently once or twice a year by first-line ferritin assay and, if necessary, by calculation of the siderophilin saturation coefficient.

In the event of iron deficiency, first-line iron supplementation is provided by prescription of an orally administered dose of 60 to 200 mg of iron, sufficiently before or after intake of any food inhibiting its absorption (tea and vegetables, particularly high-fiber nutrients).

Intravenous iron supplementation is limited to cases marked by failure and/or intolerance of oral supplementation or in the event of patent iron deficiency anemia with hemoglobin level < 10 g/dL. The maximum intravenously infused dose is 1 g.

In the few available published studies on cases following sleeve gastrectomy involving multivitamin supplementation containing sizable doses of iron (40 to 70 mg), the prevalences are extremely variable (from 4,9% [98] to 43% [15,16,55,56,60,63]). No long-term study including a sufficient number of patients is currently available.

After bilio-pancreatic deviation with or without duodenal switch, at 5 years, in a series of patients [31] with a common 100 cm loop, 40% of them required iron infusion, while 17.6% were in need of blood transfusion [99]. At 10 years [65], in a series of 153 patients with a common loop of 75 to 100 cm, iron deficiency appeared in 56.5% of patients receiving supplementation and in 58.8% of those not receiving supplementation. While 37.2% required iron infusion, anemia was found in 30.3% of the female patients.

Oral supplementation

Multivitamin/mineral supplements fail to prevent iron deficiency. More specifically, the iron doses contained in these supplements usually do not suffice to avoid deficiencies in women of childbearing age having undergone Roux-en-Y bypass surgery [43]. In the forms most habitually consumed in France, they generally contain less than 14 mg. Systematic supplementation in women of childbearing age having undergone Roux-en-Y bypass surgery is far from unanimously recommended; while reduced iron storage among these patients is well-documented, supplementation is not without drawbacks. For one thing, an appropriate dosage level has yet to be established; that said, subsequent to Roux-en-Y bypass, 200 mg of elemental iron by day may avoid iron deficiency [100]. However, while this dose can maintain iron storage (ferritinemia correction), it is unlikely to totally prevent anemia, which may be multifactorial [43,101]. Prolonged oral iron supplementation in the absence of deficiency is by no means devoid of risk [102]:

- prolonged oral iron intake can lead to malabsorption of other micronutrients, particularly zinc but also manganese, chromium and selenium [103];
- digestive tolerance is relatively unsatisfactory; digestive discomfort, constipation, nausea and diarrhea combine to render tolerance problematic [104];

- potential colic toxicity [105].

When deficiency has been observed, specific supplementation in medicinal form is called for.

Subsequent to iron deficiency correction, which is monitored by ferritin assay, the means of supplementation most apt to prevent iron deficiency recurrence remains undetermined. The existing data have not led to establishment of an optimal strategy; should it be long-term low-dose supplementation or sequential supplementation in the event of obvious lack? For the same reasons as those cited previously (interactions between micronutrients, implication of iron in colic carcinogenesis, digestive discomfort...), sequential supplementation in cases of patent insufficiency could be preferable to continuous low-dose supplementation, but as a strategy, it may be counterbalanced by risk of loss to follow-up, absence of regular biological check-up, or a factor causing persistent deficiency (vegetarian diet, heavy menstrual periods...). Modified means of contraception, diversified diet and arrival of menopause may in some cases suffice to avoid recurrent insufficiency...

Intravenous supplementation

Iron intake by intravenous injection may be necessary due to poor absorption of oral iron and/or intolerance of oral iron and/or in cases of severe deficiency. In the absence of any study specifically following bariatric surgery, intravenous supplementation is justified when hemoglobinemia is inferior to 10 g/dL, with ferritin < 30 μg/L [106,107].

Future research

The role of injectable iron.

Zinc deficiency: recommendations

In the event of zinc deficiency, supplementation needs to be associated with copper (1 mg of copper for 10 mg of zinc) and not exceed 30 mg/d except in cases of severe malabsorption; it also requires regular reassessment due to risks of interactions with other micronutrients (folate, calcium, iron...).

Oral zinc intake should take place before or after intake of multivitamin and trace element supplements.

While zinc deficiency after bariatric surgery is frequent, it is only rarely symptomatic [108,109]. Cases of acrodermatitis have nevertheless been reported [110,111]. A meta-analysis involving 23 studies has shown that zinc plasma levels decrease significantly after bariatric after the operation, whatever the type of surgery, and that the diminution persists more than 12 months postoperatively, notwithstanding intake of multivitamins containing zinc [4,112].

Supplementation must reckon with absorption competition involving zinc, iron and copper [113]. Prolonged iron supplementation by oral route thereby dose-dependently alters zinc and copper absorption [114]. Last but not least, excessive zinc supplementation can lead to sequestering of the copper ion in enterocytes secondarily to positive regulation by zinc of the copper-binding metallothionines and prevent the copper ion from circulating [115]. That is why supplementation of 8 to 15 mg of zinc should be associated with supplementation of 1 mg of copper [116,117].

Given the aforementioned absorption competitions, zinc intake needs to occur before or after iron and copper intake or iron intake [118,119]. Zinc gluconate is relatively easily absorbed and should be favored.

Following sleeve gastrectomy or Roux-en-Y bypass the zinc dose recommended to correct insufficiency is 15 to 30 mg/d. In the event of malabsorption, a daily dose of 60 mg/d can be recommended. In any case, supplementation should be regularly adjusted to the relevant circulating levels. While a recommendation of sequential supplementation may in some cases be justified, it exposes patients to risk of recurrence, especially when iron supplementation maintenance is recommended in parallel.

Future research

The future research will be:
- Zinc deficiency markers;
- Long-term supplementation (factors predictive of deficiency and doses needed to prevent deficiency).

Folate deficiency: recommendations

Preventive supplementation in folic acid (400—800 μg/d) must be systematic in any woman suspending her contraception or desiring pregnancy.

Preventive supplementation in folic acid is optimally carried out 3 months before conception (at least 4 weeks, non-optimally, prior to conception). It should be pursued up until the 12th week of amenorrhea.

Commentaries: see recommendations for bariatric surgery and pregnancy [120].

Vitamins A, E and K: recommendations

Following malabsorptive operations and long afferent loop surgery, risk of liposoluble vitamin deficiencies is increased by malabsorption.

Vitamin A deficiency rarely occurs following Roux-en-Y bypass or sleeve gastrectomy but is high following malabsorptive surgery (>25%) [65,99,121,122]. At 2 to 4 years after the operation, vitamin K deficiency was found in 50% to 70% of cases [99,116]. Vitamin E deficiency is a rare occurrence after malabsorptive surgery (5%).

In acute cases, the safety limit of Vitamin A supplementation is set at 100,000 IU (30,000 μg)/kg, and in chronic cases, at 25,000 IU (7500 μg)/d. Toxicity risks increase when RBP concentration is reduced, especially in the event of malnutrition [123]. Following malabsorptive surgery, no prospective study is currently available to assess the doses necessary to effectively prevent Vitamin A insufficiency, whether in isolation or in association. In fact, while dosages range from 4000 IU to 10,000 IU/d of retinyl palmitate, so-called empirical doses of as much as 25,000 IU/d have been reported following malabsorptive surgery [116]. In the event of patent symptomatic deficiency, even higher doses (up to

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Following surgery entailing malabsorption with steatorrhea (essentially bilio-pancreatic deviation with or without duodenal switch, omega loop gastric bypass and single anastomosis duodeno-ileal bypass with sleeve gastrectomy), it is recommended to systematically screen for deficiencies in vitamins A, E and K and to provide supplementation in the event of insufficiency.

In the event of vitamin A deficiency, while supplementation should approximate 50,000 UI a week (1 capsule of 50,000 IU a week or 1 vial of 200,000 IU a month), it may in some cases be higher, particularly in the event of symptomatic deficiency and according to degree of malabsorption and biological control. Due to risk of toxicity, excessive intake is to be avoided. It may be prudent to verify absence of pregnancy, which would necessitate cautious management.

In the event of vitamin K insufficiency, supplementation consists in 2 mg to 10 mg/week by oral route, to be reassessed according to bioassay.

In the event of vitamin E insufficiency, supplementation usually ranges from 400 to 500 IU/d (all isomers included), and may exceptionally reach 1200 IU a day, to be reassessed according to bioassay.

65,000 units/day for 2 or 3 months) may at times be called for; the exact dose will be determined according to biological monitoring.

As regards vitamin E supplementation, when taking into consideration current supplementation practices for pancreatic insufficiency associated with cystic fibrosis, the meta-analysis on this pathology carried out by Okebukola et al. ([124]: Cochrane database) showed that since recommended dietary allowance (RDA) for an adult is 15 mg/d (22.5 U), the required doses should not exceed 1200 U. Following malabsorptive surgery, a dose of 400 to 500 IU a day would appear sufficient, and a higher dose is not deemed advisable [125]. Excessive vitamin E can bring about asthenia and even, exceptionally, cerebral hemorrhage.

Analogically to the Vitamin K needs in patients suffering from intestinal insufficiency, supplementation of 10 mg/week appears sufficient.

How are dumping syndrome and reactive hypoglycemia to be treated?

The dumping syndrome (also known as early dumping syndrome) occurs 10 to 30 minutes after food intake, and appears as a form of diffuse unease with vasomotor signs (flush, hypotension, tachycardia...) et intestinal symptoms (diarrhea, nausea...). It necessitates the elimination of triggering foodstuffs, which are generally rich in simple sugars (sugar-based, sweet products) or fats, and may be hyperosmolar. Arrival of the dumping syndrome calls for renewed dietary counseling: drinking before or after food intake, fractionating meals, carefully masticating and eating serenely, achieving improved nutritional quality...

Reactive hypoglycemia (also known as late dumping syndrome), provokes adrenergic (sweat, palpitations, trembling...) and even neuroglycopenic symptoms (confusion, diplopia...) and is concomitant with glycemia < 0.5 g/L. It generally occurs 1 to 3 hours after carbohydrate intake and necessitates dietary counseling, which will be largely aimed at reducing the glycemic index (GI) of ingested food (food with GI > 70 is to be avoided) and at fractionating meals.

In the event of repeated episodes of reactive hypoglycemia not responding or insufficiently responding to dietary management, treatment by alpha-glucosidase inhibitor (acarbose) may be effective.

In the event of hypoglycemic episodes or unease persisting in spite of dietary counseling, search for another cause is desirable, if only in view of excluding organic hypoglycemia or other etiologies.

Treatment and management are based on:

- dietary measures often suffice to avoid hypoglycemia. The objective is to reduce not so much the quantity of carbohydrates as the glycemic index of foods ingested (rather than meals eaten); sweet beverages and sugary food consumed outside of meals are to be ruled out [126]. Indeed, following total or partial gastrectomy a food's glycemic index (and not that of a meal, given that there can no longer be any effect on gastric emptying...) is of decisive importance. Addition of food slowing gastric emptying makes no difference;
- acarbose: notwithstanding the absence of market authorization, acarbose is a commonly used treatment; while it cannot effectively replace dietary measures, acarbose slows starch digestion and reduces the hyperglycemic effects of meals. It has been successfully tested in various studies; however, compliance is poor due to bothersome side effects (flatulence) [127,128]. Some authors have associated verapamil with acarbose [129];
- diazoxide has also been successfully tested in a few patients [130] but is only exceptionally prescribed, especially insofar as it exposes users to the risk of diabetes;
- while bypass reversion is the ultimate solution when medical treatments do not suffice, it is extremely rare.

Patients with severe hypoglycemia must be referred to a specialized center.

Future research

Impact of an early and systematic prevention strategy.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jviscsurg.2020.10.013.

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Pour citer cet article : Quilliot D, et al. Recommendations for nutritional care after bariatric surgery: Recommendations for best practice and SOFFCO-MM/AFERO/SFNCM/expert consensus. Journal of Visceral Surgery (2020), https://doi.org/10.1016/j.jviscsurg.2020.10.013