Post bariatric surgery Hyperoxaluria

Mojgan mortazavi

Professor of nephrology

Isfahan kidney diseases research center

- The obesity epidemic has been related to sedentary lifestyle, increased use of processed or high caloric foods, and other trends.
- A prospective study of three large cohorts found that compared to matched controls, obese patients were 1.44 (men) and 1.92

(women) times as likely to form stones [2].

Other studies have shown that obese patients have an increased excretion of stone-promoting substances

- The newest trend in treatment of morbid obesity is Roux-en-y gastric bypass or gastric banding. The rate at which these procedures are being performed has increased 600% from 1996 to 2001.
- In the 1970s, jejunoileal bypass led to significant complications,

including nephrolithiasis, ranging from 11% at 1 to 5 years [5] to as high as 39% after 15 years

- In contrast, modern bariatric surgery procedures, which are touted to cause less malabsorption than jejunoileal bypass, have been postulated to have less impact on urinary stone risk.

- hyperoxaluria was recently confirmed to be the most significant abnormality in urinary stone risk profile after modern bariatric surgery
- Furthermore, hyperoxaluria has been shown to increase as time from surgery increases

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UROLOGY - CASE REPORT

Hyperoxaluria after modern bariatric surgery: case series and literature review

Jared M. Whitson · G. Bennett Stackhouse · Marshall L. Stoller

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- We identified 39 patients who had severe hyperoxaluria (oxalate [75 mg/day), 26 of whom had clinic charts available for review of medical and surgical histories. Five of these 26 patients were found to have a history of Roux-en-y gastric bypass surgery
- No prior to weight reduction surgery. In addition, none of the operations had taken place within the year prior to 24-h urine collection.

- Twenty-four-hour urine collections of all patients referred to a tertiary clinic for nephrolithiasis in the past 4 years were reviewed.Those patients with severe ([75 mg/day) hyperoxaluria were identified.

- Retrospective chart review was performed to identify those patients with a history of bariatric surgery.

Results

- Out of all stone formers within our 24-h urine collection database, 39 patients had severe hyperoxaluria (oxalate [75 mg/day). Twenty-six patients had complete information for review. Five patients had a history of bariatric surgery

conclusion

- Appropriate medical management, in particular oral calcium and citrate supplementation, and perhaps most importantly aggressive fluid intake can mitigate some of the effects of enteric hyperoxaluria

caused by fat malabsorption after modern bariatric surgery.

conclusion

- Despite the anticipated significantly higher oxalate levels, compared with other hyperoxaluric patients, modern bariatric surgery patients had a dramatically lower supersaturation of calcium oxalate, predominantly due to higher urinary volume and lower urinary calcium excretion. Appropriate medical management, in particular oral calcium supplementation and aggressive fluid intake may mitigate some of the effects of enteric hyperoxaluria after modern bariatric surgery.

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Case Report

CASE REPORT

A case of reversible hyperoxaluria nephropathy early after roux-en-y-gastric bypass induced by vitamin C intake

Said Farhat[1,*], Abtar Houssam[2], Ali Ghassaoui[3], El Ajami Khaled[1], and Mansour El Khoury[3]

[1]Gastroenterology Division, Saint Georges Hospital University Medical Center, University of Balamand, Beirut, Lebanon, [2]General Surgery Division, Central Military Hospital, Beirut, Lebanon, and [3]General Surgery Division, Saint Georges Hospital University Medical Center, University of Balamand, Beirut, Lebanon

*Corresponding address. Saint Georges Hospital University Medical Center, University of Balamand, P.O. Box 166 378, Achrafieh, Beirut 11 00 2807, Lebanon. Tel: +961-1-441-000 or +961-1-575-700; Fax: +961-1-582-560; E-mail: saidfarhat@hotmail.com

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- Roux-en-y-gastric bypass (RYGB) is the most commonly performed bariatric procedure worldwide which is taking the lead inresolving of comorbid conditions. Short- and long-term complications of RYGB procedure have been recognized, including osteopenia, osteomalacia and more rarely neurological disorders.
- Oxalate nephropathy is a complication of RYGB that has been described earlier in the literature and may end with renal failure and dialysis if not recognized and treated early.

- The etiology of this phenomenon is still unclear, but the length of common limb remains the theory that mostly contributed to its development.

- We believe that this limb should be more than 100 cm to prevent severe malabsorption. Here, we report a reversible case of oxalate nephropathy 3 months after RYGB in a 51-year-old patient

- Roux-en-y-gastric bypass (RYGB) is the most common procedure

done and leads to improvements in weight, sugar levels,insulin resistance, cardiovascular risk factors and sleep apnea

- Although both short- and long-term complications of RYGB procedure

have been recognized, including osteopenia, osteomalacia,and more rarely neurological disorders, the procedure has been deemed relatively safe and effective

- Recent data suggest that modern bariatric procedures, such as

RYGB, may also impart a 2-fold increased risk of nephrolithiasis

- whereas 20–75% of patients may have hyperoxaluria, including 20% with very high urine oxalate levels, also putting them at considerable

risk of oxalate nephropathy

Table 1. Patient's demographics and biochemical results

Characteristics	
Sex	Male
Age (year)	51
BMI (kg/m^2)	42
Renal function	Normal
Diabetes mellitus	Yes
Hypertension	No
Hyperlipidemia	No
Chronic obstructive pulmonary disease	No
Smoker	Yes
Biochemical results on admission	
Serum creatinine (mg/dl)	8.42
24 h Urine oxalate level (mg)	80

- Nasr et al. [3], 11 patients presented with acute kidney injury (AKI) 6 months after RYGB and were diagnosed with oxalate nephropathy.
- In another study done by Sinha et al. [1], 31 patients had oxalate nephropathy 2.2 years post RYGB.
- Oxalate nephropathywas seen also in kidney transplant recipient patients 27 and 7 years, respectively, after RYGB as described by Troxell et al. [2].
- Matlaga et al. [4] showed that nephrolithiasis incidence after RYGB is 7.65% (in a study with 4639 RYGB patients) when compared with 4.63% in the same number of patients that did not undergo bariatric operation. Our patient presented with AKI (creatinine = 8.42 mg/dl) 3 months after the operation, which has never been reported before.

- Vitamin C is believed to result in a hyperoxaluric state. The recommended
- daily intake of vitamin C is between 75 and 90 mg/
- day. Several cases of oxalate nephropathy have been reported
- with vitamin C intake <2 g/day [6]. The mechanism of oxalate deposit
- formation is contributed by the increased fat malabsorption
- which leads to increased colonic fat that binds to free calcium, increasing
- unbound oxalate that is able to cross the colonic mucosa.
- In malabsorptive states (like after RYGB), the percentage
- of oxalate absorbed from the gut and excreted in urine can be
- markedly increased and hyperoxaluria often correlates with
- steatorrhea

The pathogenesis of hyperoxaluria after RYGB

- The pathogenesis of hyperoxaluria after RYGB is not completely

understood, but the length of the common channel is one of the most important factors leading to significant fat malabsorption in some, causing enteric hyperoxaluria

- Although RYGB operation with a Roux limb of <150 cm in length is generally believed not to cause fat malabsorption, data suggest that hyperoxaluria may indeed occur, and represent a risk for calcium oxalate nephrolithiasis [

- Some earlier studies of patients with inflammatory bowel disease

correlate the degree of hyperoxaluria with the degree of steatorrhea; this pathogenesis might explain why patients who have had distal RYGB (through creation of a longer Roux limb and subsequently shorter common channel for nutrient absorption) can be at higher risk for developing calcium oxalate kidney stones compared with standard RYGB patients.

- The goal of management is to reach normal creatinine levels and normal diuresis.
- Many treatments can be applied starting with oxalate-free diet, limit fat intake, appropriate hydration to maintain urine output of at least 2 l, oral calcium supplementation and reversal of the surgery
- This strategy, if applied early, can reverse the nephropathy and can prevent irreversible tubular damage leading to dialysis.

- More recent treatments like supplementation of Oxalobacter formigenes bacteria, a normal commensurate part of the human gut microflora which metabolizes oxalate as an energy source have been applied and showed promising results by reducing the urinary oxalate levels

- In conclusion, surgeons should be aware of this complication and be aggressive in their treatment strategies in order not to reach dialysis.
- We suggest counting accurately the length of the common channel during each gastric bypass as well as maintaining oxalate-free and fat-free diet with oral calcium supplementation postoperatively.

nutrients

MDPI

Review

Dietary Recommendations for Bariatric Patients to Prevent Kidney Stone Formation

Milene S. Ormanji [1,†], Fernanda G. Rodrigues [1,2,†] and Ita P. Heilberg [1,2,*]

1 Nephrology Division, Universidade Federal de São Paulo, São Paulo 04023-062, Brazil; milene.ormanji@gmail.com (M.S.O.); fernanda.gr91@gmail.com (F.G.R.)
2 Department of Nutrition, Universidade Federal de São Paulo, São Paulo 04023-062, Brazil
* Correspondence: ita.heilberg@gmail.com; Tel.: +55-(11)-5576-4848 (ext. 2465)
† Contributed equally.

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Abstract: Bariatric surgery (BS) is one of the most common and efficient surgical procedures for sustained weight loss but is associated with long-term complications such as nutritional deficiencies, biliary lithiasis, disturbances in bone and mineral metabolism and an increased risk of nephrolithiasis, attributed to urinary metabolic changes resultant from low urinary volume, hypocitraturia and hyperoxaluria. The underlying mechanisms responsible for hyperoxaluria, the most common among all metabolic disturbances, may comprise increased intestinal oxalate absorption consequent to decreased calcium intake or increased dietary oxalate, changes in the gut microbiota, fat malabsorption

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Introduction

- Obesity is one of the most important worldwide public health challenges predisposing to severe
- comorbidities such as diabetes mellitus, cardiovascular disease, cancer, sleep apnea and hypertension [1].
- Considering the diculties regarding diet therapy as a long-term control of morbid obesity, bariatric
- surgery (BS) translated into an ecient method for sustained weight loss

- BS procedures comprise restrictive techniques like gastric banding and sleeve gastrectomy, malabsorptive techniques such as biliopancreatic diversion and duodenal switch, or a
- combination of both as in a Roux-en-Y gastric bypass (RYGB), one of the most common surgical procedures performedover the last years.

- Although BS is considered an ecacious technique with benefits concerning the
- treatment of comorbidities of the morbidly obese patients, it may bring long-term complications such as nutritional deficiencies, biliary lithiasis, disturbances in bone and mineral metabolism and an increased risk of nephrolithiasis

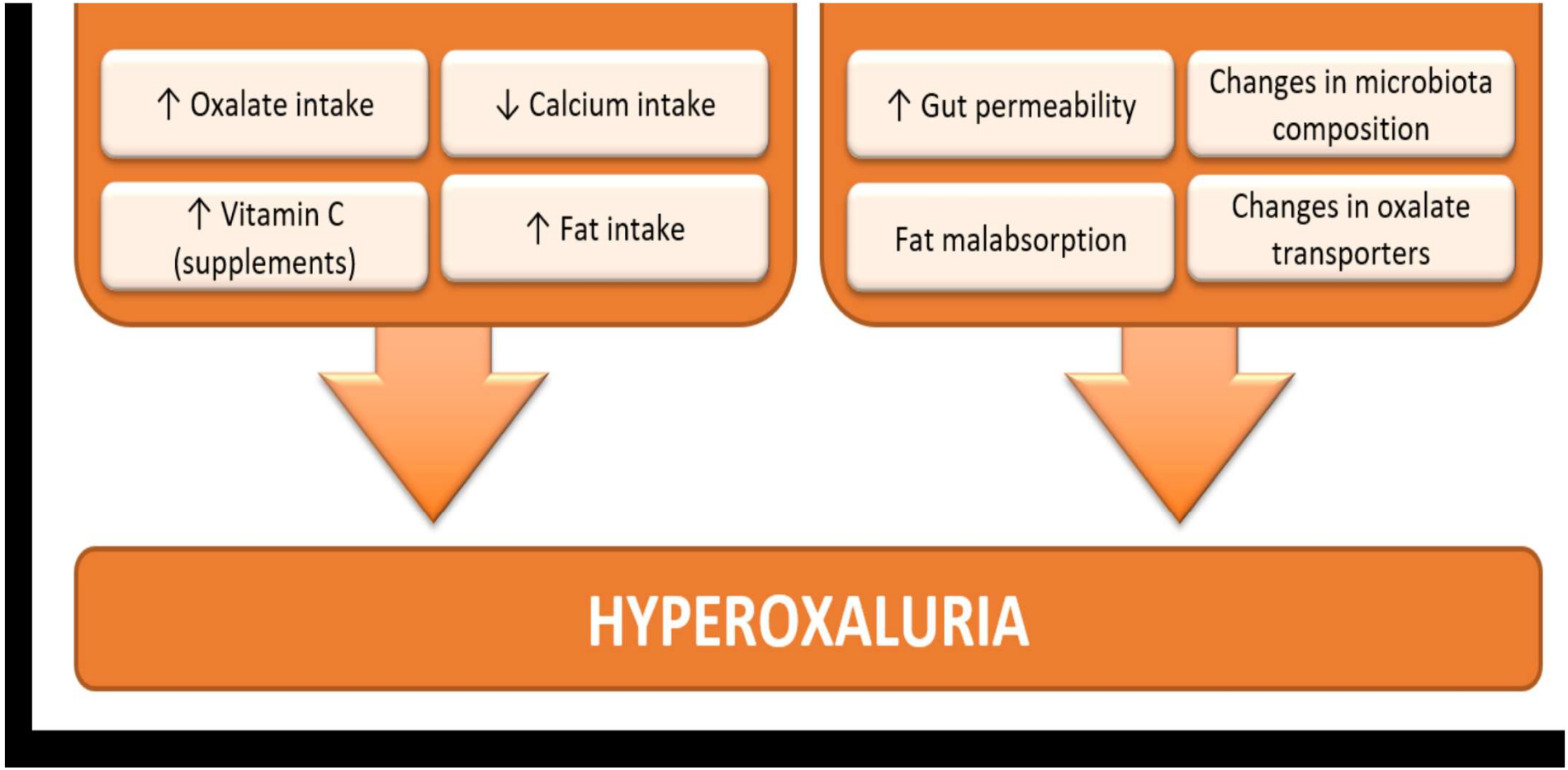
Nephrolithiasis

- Nephrolithiasis arises from urinary metabolic changes in these patients, such as low urinary
- volume, hypocitraturia and hyperoxaluria.

Secondary hyperoxaluria

- certainly the case in patients that have undergone BS and represents the most frequent metabolic disturbance detected among them, with prevalence rates ranging from 29% to around 67% at 3 months and 2 years after BS

Hypothetical underlying mechanisms for hyperoxaluria after bariatric surgery (BS).



- A diet rich in oxalate and/or poor in calcium decreases the generation of unabsorbable calcium oxalate (CaOx) complexes ultimately leading to a higher amount of free oxalate in the intestinal lumen

- The occurrence of hyperoxaluria following BS can be also associated with increased fecal fat malabsorption, probably due to the higher amount of unabsorbed bile and fatty acids which saponify intestinal calcium, limiting the amount of luminal free-calcium binding with oxalate

Dietary Recommendations

Oxalate

- Although a low-oxalate diet is recommended to prevent hyperoxaluria and stone formation after BS, the lack of information about oxalate content in foods can be an obstacle while trying to restrict oxalate from the diet

Table 1. Oxalate content in foods (mg/100g).

Food	Description	Oxalate Content (mg/100 g)	References
Spinach	Cooked	755–957	[38,50,54]
Spinach	Raw	656–900	[38,50,54]
Rhubarb	Raw	541	[38]
Beet	Roots	76	[38]
Okra	Cooked	45–70	[38,40]
Turnip	Raw	30	[38]
Oca	Cooked	373	[55]
Potato	Baked	24–97	[38,40]
	Chips	75	[38]
	French fries	20–51	[38,40]
Sweet potato	Baked	0.2–86.9	[38,40]
Legumes	Navy Beans	56–76	[38,56]
	Black Beans	71	[56]
	Fava Beans	20	[38]
	Red Kidney Beans	13–26	[38,56]
	Pinto Beans	25–29	[56]
	Soybeans	7.0–57	[38,56]
	Lentils	8.0–39	[38,56]
Star fruit	Raw	80–730	[42,57]
Raspberry	Raw	48	[38]
Orange	Raw	29	[38]
Avocado	Raw	19	[38]
Nuts	Almonds	435–491	[38,56]
	Cashews	175–263	[38,56]
	Walnuts	77–111	[38,56]
	Peanuts	96–148	[38,56]
	Peanut Butter	65	[38]
	Pistachios	46–51	[38,56]
	Pecans	12–66	[38,50,56]
	Sunflower seeds	12	[38]
	Macadamia nuts	40–43	[56]
Bran	Rice bran	281	[38]
	Oat bran	10	[38]
	Wheat bran	34	[38]
	Whole wheat flour	29–67	[38,56]
	White flour	17–41	[38,56]
Chocolate *	Milk chocolate bar #	18–140	[38,56]
	Dark Chocolate bar #	155–485	[58]
	Cocoa powder #	84–783	[38,58]
Coffee *	Filtered	1.0	[38]
	Decaffeinated, filtered	2.0	[38]
Tea *	Black, Brewed	4.0–16	[38,59]
	Green, Brewed	0.3–2.3	[59]

* Variable according to the brand; # variable depending on the amount of cocoa.

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Calcium and Vitamin D

- Calcium absorption predominantly occurs in the duodenum and proximal jejunum and is dependent on vitamin D levels
- Due to fat malabsorption, all fat-soluble vitamins (A, D, E and K) are at risk of deficiency among bariatric patients
- Schafer et al. [61] demonstrated that even patients with acceptable levels of vitamin D (30 ng/mL) and maintained under an adequate calcium intake (>1200 mg/day) had a marked decrease in intestinal calcium absorption from 33% preoperatively to7% after 6 months of RYGB.
- The common use of proton-pump inhibitors by bariatric patients may also

aect calcium absorption contributing to the exacerbation of such deficiency

- In summary, the recommended amount of calcium intake after BS should be at least 1200–1500 mg/day, provided by diet or supplements and at least 3000 IU of Vitamin D per day adjusting to maintain adequate serum levels

Vitamin B6

- Considering endogenous metabolism, vitamin B6 (pyridoxine), in the form of pyridoxal phosphate,is a required cofactor of the enzyme alanine-glyoxylate aminotransferase (AGT) for the transamination

of glyoxylate to glycine

- When vitamin B6 status is inadequate for enzyme activity, a higher amount of glyoxylate is converted to oxalate by the lactate dehydrogenase
- The current recommended dietary allowance (RDA) for vitamin B6 is around 1.3 mg/day for healthy individuals [75] and the richest sources of vitamin B6 include fish, beef liver and other organ meats, potatoes and other starchy vegetables, and non-citrus fruits

- In summary, although patients undergoing a BS are under risk of several micronutrient
- deficiencies [81], there has been no study to date performed among bariatric patients aimed to
- address the eects of vitamin B6 on preventing kidney stones and the latter is not part of the
- recommended supplement doses of vitamins after BS as yet.

Vitamin C

- Another oxalate-related metabolic pathway is derived from vitamin C (ascorbic acid, ascorbate),
- an essential micronutrient which humans cannot synthesize due to the lack of the last enzyme in
- the biosynthetic pathway. The current RDA for vitamin C is 90 mg/day for men and 75 mg/day for
- women [75]. Although this recommendation can be achieved with a diet rich in fruits and vegetables,
- ascorbic acid supplements have been widely used for many purposes. Epidemiological data revealed
- that vitamin C supplements (> 1000 mg/day) were associated with a 16% increase in incidence of kidney
- stones and increases in oxaluria among men [82]. A metabolic study conducted by our group in adult
- calcium stone-forming patients [83] has shown a significant increase of 61% and 41% in mean urinary
- oxalate after taking 1 and 2 g of vitamin C, respectively, while other investigators reported increases
- of 33% among SF taking 2 g/day [84]. Conversely, Massey et al. [85] found no oxaluric response to
- vitamin C in many individuals.
- In summary, given that vitamin C deficiency may occur after BS [81,86], but harmful eects
- upon oxaluria can exist, a note of caution should be taken when prescribing ascorbic acid to BS
- patients, especially for those with a previous history of kidney stones, and urinary oxalate levels must
- be monitored.

Citrate and Potassium

- Hypocitraturia is a common but not a uniform urinary disturbance found after RYGB, ranging
- from 34% to 63% of patients when present [87–89]. The reasons for hypocitraturia have not been fully
- elucidated since underlying metabolic acidosis, excessive salt and/or animal protein intake have not
- been observed in most studies [14,87]. Moreover, considering the weight loss after the procedure, low
- urinary pH induced by obesity should rather be restored to higher values [90].
- In summary, aiming to increase both potassium and citrate intakes, recommendations after BS
- should consist of at least 2–3 servings/day of vegetables and fruits (specially the citric ones), based on a
- nutritional pyramid for this population [101

Probiotics

- In summary, although the trials with probiotics designed to degrade oxalate in dierent clinical
- settings remain still under debate [22,113] and there is no specific data for bariatric patients,
- the individualized prescription can be considered as an alternative and adjuvant approach that
- warrants further investigation in terms of dosing, type and timing of administration

Protein and Sodium

- After BS, animal protein consumption is sometimes compromised because of reduced gastric
- capacity and aversion to certain foods [114]. Golzarand et al. [99] have shown that among patients
- who underwent RYGB or Sleeve gastrectomy, the reduction of protein intake was around 54% and 65%,
- respectively, leading to the loss of fat-free mass rather than the desired loss of fat mass. According to the
- American Society for Nutrition the total protein intake recommendation should be individualized and
- guided by a registered dietitian, reaching a minimal daily intake of 60 g, with an adequate intake up to

- In summary, minimal daily intake of 60 g of protein must be achieved by BS patients, and aiming to
- prevent stone formation an adequate intake of 0.8–1.0 g/Kg IBW/day should be considered. As there is
- a lack of a particular dietary guidance regarding sodium intake by BS patients, the recommendation for
- the general population of 2 g/day (5 g of NaCl), according to theWorld Health Organization [119], might
- be suggested. Besides salt, the intake of high-sodium food items such as processed and ultra-processed
- foods should be limited not only to prevent stones but also to help in controlling weight loss after
- BS [120].

Fluids

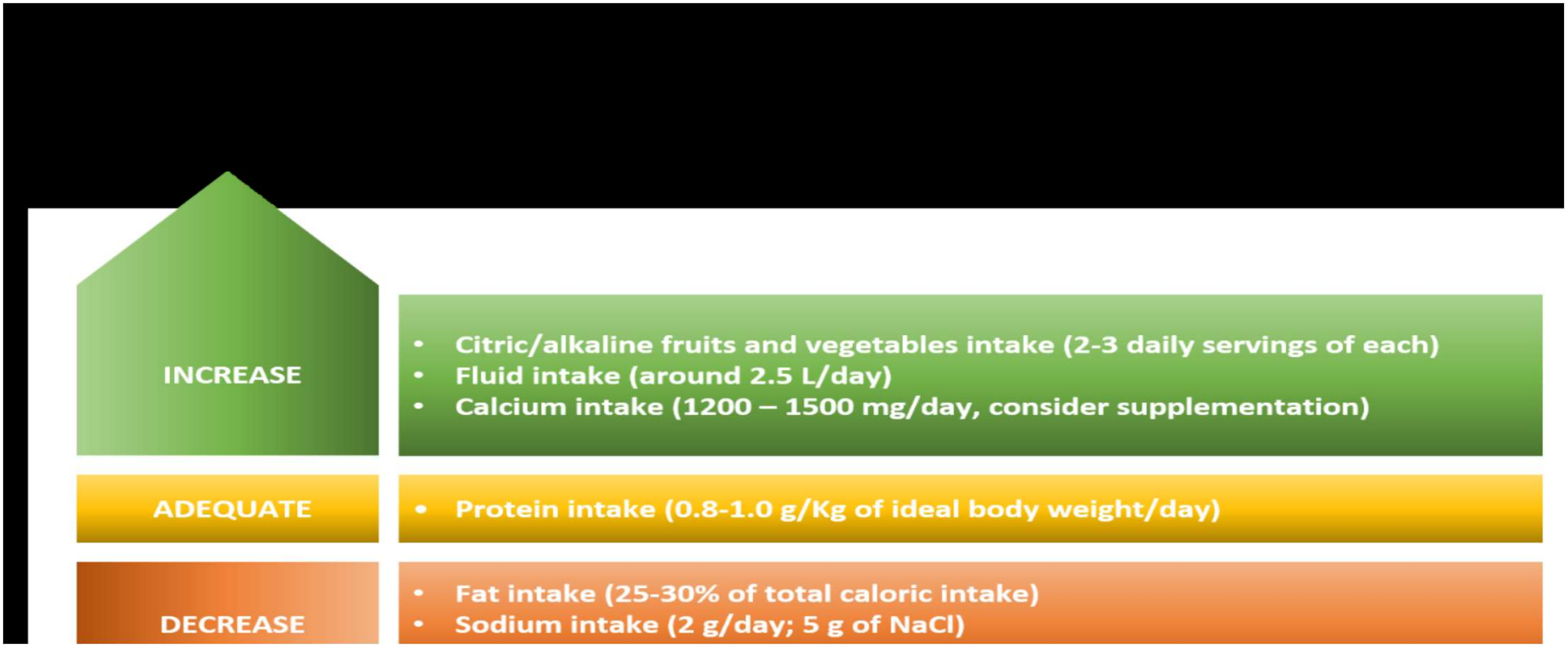
- It is well established that most BS patients consume a lower amount of fluids due to the small
- gastric pouch [11,14,88]. In our outpatient unit we have detected a significantly lower urinary volume
- reflecting such reduced fluid intake even many years following BS [14]. In order to prevent recurrence,
- SF have been advised to have an appropriated fluid intake, specially water, aimed to achieve a urinary
- volume of approximately 2.5 L/day or 30 mL/Kg/day [121]. However, there is no specific guidance
- for BS patients to prevent stone formation, although they are encouraged to drink about 1.8 L/day
- even when fluid intake is dicult soon after surgery [101]. Moreover, they should avoid high-calorie
- beverages, such as soft drinks, sport drinks and processed juices, replacing them by water and natural
- fruit juices. In order to prevent the discomfort or symptoms of Dumping Syndrome, patients can limit
- fluids to 4 oz (1/2 cup) during mealtimes, and drink liquids around 30 min before eating or 1 h after
- eating instead.
- In summary, assuming the increased risk of kidney stones when the urinary volume is low,
- BS patients should be recommended to have a fluid intake of around 2.5 L/day.

Fat

- Malabsorptive procedures, such as RYGB, result in fat-malabsorption, contributing to weight loss
- due to caloric deficit [122]. Besides, it is well established that fat malabsorption is strongly associated
- with enteric hyperoxaluria and fat-soluble vitamins deficiencies [16].

- IN SUMMARY

- In conclusion, specific guidelines to prevent nephrolithiasis after bariatric surgeries are still
- lacking. Therefore, the present review, based on the available literature, suggests the main nutritional
- recommendations for BS patients to reduce the risk of stone formation or recurrence for those who
- already had stones before the surgery (Figure 2).


INCREASE
• Citric/alkaline fruits and vegetables intake (2-3 daily servings of each)
• Fluid intake (around 2.5 L/day)
• Calcium intake (1200 – 1500 mg/day, consider supplementation)
ADEQUATE
• Protein intake (0.8-1.0 g/Kg of ideal body weight/day)
DECREASE
• Fat intake (25-30% of total caloric intake)
• Sodium intake (2 g/day; 5 g of NaCl)