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Factors Associated With Weight Loss After Laparoscopic Adjustable Gastric Banding in Adolescents With Severe Obesity

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ABSTRACT

Background: Childhood obesity is associated with many comorbidities. Bariatric surgery is known to be efficient for reducing weight in adolescents.

Objectives: The primary outcome was to identify somatic or psychosocial factors associated with success at 24 months after a laparoscopic adjustable gastric banding (LAGB) procedure in our cohort of adolescents with severe obesity. Secondary endpoints were to describe weight loss outcomes, comorbidity resolution, and complications.

Methods: We have retrospectively reviewed medical records of patients who had LAGB placed between 2007 and 2017. Factors associated with success at 24 months after LAGB were researched, with success being defined as positive percentage of excess weight loss (%EWL) at 24 months.

Results: Forty-two adolescents underwent a LAGB procedure, the mean %EWL was 34.1% at 24 months, with improvement in most comorbidities and without major complications. Having lost weight before surgery was associated with success, whereas a high body mass index at surgery was associated with a higher risk of failure. No other factor was found to be associated with success.

Conclusion: Comorbidities mostly improved 24 months after LAGB and no major complication occurred. Having lost weight before surgery was associated with a successful surgery, whereas a high body mass index at surgery increases the risk of failure.

Key Words: morbid obesity, bariatric surgery, adolescent, laparoscopic adjustable gastric banding, weight loss

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The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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What Is Known

- Laparoscopic adjustable gastric banding is known to be efficient for reducing weight in adolescents.
- Laparoscopic adjustable gastric banding has a lower complication rate than other bariatric surgeries.

What Is New

- Having lost weight before surgery was associated with success, whereas a high body mass index at surgery was associated with a higher risk of failure.
- However, the present study did not find other factors associated with success, in particular, factors that may indicate good personal and family eating behavior.

INTRODUCTION

In France, 16%–19% of children are overweight or obese, with 4%–5% being obese during the 2000s (1). Childhood obesity leads to many comorbidities (2) and is linked to increased cardiovascular mortality in adulthood (3).

First line treatment of childhood obesity consists in establishing lifestyle changes and always remains the first step. Nevertheless, its impact has at least a small effect on weight loss (4) and the addition of experimental pharmacological treatments only resulted in a small improvement in terms of weight loss results (5,6).

Surgical treatment has proved its efficiency in reducing weight in adolescents (7), even if the type of bariatric surgery still remains debated and varies across countries and teams. The proposed surgical intervention in adolescents can be purely restrictive (laparoscopic adjustable gastric banding [LAGB] or laparoscopic sleeve gastrectomy), or both restrictive and malabsorptive (Roux-en-Y gastric bypass).

In France, recommendations from the health authorities (Haute Autorité de Santé) on bariatric surgery in adolescents were published in 2016 (8). They define the required factors for surgery, in particular being 13 years old or above, and having a body mass index (BMI) ≥ 35 kg·m^{-2} with at least 1 severe comorbidity or a BMI ≥ 40 kg·m^{-2}. It does not recommend a specific type of surgery but instead advocates a medical survey realized by a specialized multidisciplinary team comprising at least pediatricians, nutritionists, pediatric psychiatrists, and surgeons.

Nearly 1500 adolescents have undergone bariatric surgery in France in the last 20 years, according to an assessment by the French Health Insurance, half of them having a LAGB (9).

In our specialized care centre, the only procedure performed since 2007 in adolescents with obesity has been the LAGB (10). Even if all patients were treated according to the same standardised care pathway, outcomes seemed uneven, in particular with regard to weight loss. In the adult population, factors have been associated with success, such as the number of inflation of the LAGB (11), the male gender, the postoperative self-reported adherence to diet (12), the patient's follow-up (13), and the amount of previous weight loss before evaluation for bariatric surgery (14).

Our aim was thus to investigate preoperative factors associated with successful bariatric surgery in adolescents. The primary outcome of this study was to identify somatic or psychosocial factors associated with success at 24 months after a LAGB procedure in our cohort of adolescents with severe obesity. The secondary endpoints were to describe weight loss outcomes, comorbidity resolution, and complications after LAGB.

METHODS

Study Design and Participants

All patients having a LAGB placed between October 2007 and August 2017 in our specialist care facility for severe pediatric obesity were prospectively included in this study. This adolescent LAGB programme was approved by the ethics committee of the University Hospital of Angers in 2007 and informed consent was obtained from the patient and their parents. The cohort survey has been declared in ClinicalTrials.gov (NCT04766801).

Criteria to access to bariatric surgery were:

- Age ≥14 years and Tanner stage ≥ IV;
- BMI ≥40 kg·m^{-2} or BMI ≥35 kg·m^{-2} with at least 1 comorbidity (including diabetes or insulin resistance, sleep apnea, high blood pressure (BP), dyslipidemia, nonalcoholic fatty liver disease [NAFLD], psychosocial complications linked to obesity or major deterioration in quality of life);
- Regular psychiatric appointments;
- Ability to follow essential changes in dietary habits and lifestyle;
- Ability of the child and the child's family to take on board the risks and the subsequent therapeutic measures (nutrient supplementation, regular medical follow-up).

Exclusion criteria for LAGB were any criteria precluding surgery: decompensated or untreated psychiatric disorders, syndromic obesity with severe mental retardation, being pregnant or breastfeeding or planning a pregnancy in the 2 years following surgery, or lack of familial support.

Preoperative and Follow-Up Assessments

Patients were included in our adolescent LAGB programme during a first consultation consisting of a global assessment including individual medical and family history, complete physical examination, and basic laboratory examinations. Examinations were then completed with bone mineral density, metabolic, mineral and vitamin assessment and were the same at inclusion and during follow-up re-evaluations.

All adolescents had a pediatric psychiatric evaluation before surgery. During this consultation, information gathered was the age of weight gain as declared by the parents along with a potential triggering event, the timeframe between perceived weight problem and treatment, and the origin of the request for surgery (adolescent, parents or physician). Family adversities were also noted (divorce, death or absence of a parent, sick parent, unfulfilled emotional needs, mistreatment, sexual abuse, or child welfare procedures), as were school difficulties (grade repetition, school dropout, integration classes, specialist teaching, medico-pedagogic institute, or distance learning). Finally, the presence of emotional suffering, emotional eating (boredom, loneliness, pleasure, anger, sadness, stress, or comfort) (15) and eating disorders (anorexia nervosa, bulimia, binge eating disorder) were evaluated (16).

Patients were then monitored by regular consultation with a dietitian, a pediatric psychiatrist and a pediatric endocrinologist over, at least, 6 months before surgery. If they demonstrated good compliance, consent for bariatric surgery was given by a multidisciplinary committee. Compliance was assessed by participation in sports workshops, attendance at appointments with the various professionals, and compliance with dietary rules and advice. We estimated very good compliance as representing an appointment attendance rate higher than 90% among the adolescents; good compliance as representing 70%–89% attendance, and average compliance as representing 50%–69% attendance with poor compliance representing a less than 50% attendance rate. After surgery, patients were followed up every 3 months for the first year, every 6 months until the third year, and then once a year by a multidisciplinary team (including dietitian, psychiatrist, endocrinologist, and surgeon).

Surgery and Inflation of the LAGB

The Midband LAGB (M.I.D., Dardilly, France) was placed using the laparoscopic "pars flaccida" technique and was initially kept deflated. There was no systematic postoperative vitamin supplementation. Postoperative control occurred 6 weeks after surgery and was associated with the first inflation of the LAGB. Further adjustments were made thereafter if needed, based on weight loss efficiency, tolerance of a solid meal and evaluation of the feeling of hunger. Weight regain or plateauing of weight reduction despite good nutritional habits along with the loss of light and transient dysphagia was the indication for band filling.

Metabolic Assessment

At each visit, weight, height, BMI, and percentage of excess weight loss (%EWL) were collected (17), with %EWL calculated as (initial weight − postoperative weight)/(initial weight − ideal weight), with ideal weight being the weight corresponding to a BMI of 25 kg·m^{-2} (17). Hypertension and sleep apnea were assessed through BP measurement and polysomnography, respectively. Normal BP was defined as BP <120/80 mm Hg, hypertension as ≥130/80 mm Hg, and elevated BP as the range in-between (18). Sleep apnea was diagnosed when the obstructive apnea–hypopnoea index was ≥15 per hour (19).

Fasting insulinemia, triglycerides, total cholesterol, high-density lipoprotein (HDL) cholesterol, liver enzymes, vitamins, and mineral trace elements were measured every 6 months with commercially available kits. Low-density lipoprotein was calculated with the Friedewald equation. Insulin resistance was defined as fasting insulinemia over 2 standard deviations (SD) for age and sex, using the reference values of healthy French children and adolescents from 7 to 20 years old (20). With the same reference values, lipid abnormalities were defined as hypertriglyceridemia, hypercholesterolemia, and high low-density lipoprotein cholesterol when the value was >2 SD and low HDL cholesterol when HDL cholesterol was <2 SD. NAFLD was defined by elevated liver enzymes or liver hyperechogenicity on abdominal ultrasonography (21). At 6 and 12 months after surgery and then each year, patients had an oral glucose tolerance test (75 g glucose intake, with plasma glucose and insulin measurements at 0, 30, 60, 90, and 120 minutes). According to the International Society for Pediatric and Adolescent Diabetes recommendations in 2018 (22), we defined impaired fasting glucose as fasting plasma glucose between 100 and 125 mg/dL, and impaired glucose tolerance as 2 hours post-load plasma glucose 140 to <200 mg/dL. Diabetes mellitus was defined as fasting plasma glucose ≥126 mg/dL, or 2 hours post-load plasma glucose ≥200 mg/dL.

Serum calcium and phosphorus, vitamin D, serum iron, ferritin, transferrin saturation coefficient, zinc, magnesium, vitamin A, B1, B9, B12, and E were measured before surgery, at 6 months, and then once a year in absence of deficiency. Bone mineral density was measured every year.

Complications were classified according to the Clavien-Dindo classification (23), with major complications defined as class IV or V complications, including death and major life-threatening conditions, such as hemorrhage, gastric, or intestinal leakage or peritonitis.

Factors Associated With Success

Our primary outcome was to identify somatic or psychosocial factors associated with success of the LAGB 24 months after surgery in our cohort of adolescents, success being defined by a positive %EWL 24 months after surgery. To deal with the potential loss of follow-up at 24 months, %EWL at 24 months was calculated using the maximum weight measured either at 24 months ± 6 months.

Statistical Analysis

Quantitative variables were expressed as mean and SD and compared using Student's *t* test. Qualitative variables were expressed as percentages and compared using McNemar or chi-square tests. The relationship between interest factors and success at 24 months was explored using logistic regression. All the tests were 2-sided, considering a *P* value threshold at 0.05. The statistical analyses were performed using R software (R Core Team 2019, R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Patient Characteristics

Forty-two patients underwent LAGB between October 2007 and August 2017. At inclusion, mean age was 16 ± 1.1 years old, patients were mostly women (83%), with a mean BMI of 41.8 ± 4.6 kg·m^{-2}. Characteristics at inclusion are reported in Table 1.

Weight Loss Outcome, Comorbidity Resolution, and Complications During Follow-Up

Twenty-four patients completed a 24-month follow-up after surgery, with a mean excess weight loss percentage (%EWL) of 34.1% ± 38.9 and a mean BMI loss of 5.6 kg·m^{-2} ± 6.1, compared with time of surgery (Table 2).

TABLE 1. Inclusion of demographic, psychosocial, and clinical characteristics of patients

Characteristics	N = 42
Mean age, y	16.0 ± 1.1
Gender, female	35 (83%)
Birth weight, kg	3.2 ± 0.6
Family history of obesity (first degree)	14 (33%)
Family history of bariatric surgery (first and second degrees)	7 (17%)
Individual medical history of psychiatric disorder	21 (50%)
Family history of psychiatric disorder (first degree)	14 (33%)
Adolescent requesting surgery	34 (81%)
Family adversities (divorce, death or absence of a parent, sick parent, unfulfilled emotional needs, mistreatment, sexual abuse, or child welfare procedures)	30 (71%)
School difficulties (grade repetition, school dropout, integration classes, specialist teaching, medico-pedagogic institute, or distance learning)	9 (21%)
Verbalization of psychological suffering	36 (86%)
Emotional eating (boredom, loneliness, pleasure, anger, sadness, stress, or comfort)	24 (57%)
Eating disorders (anorexia nervosa, bulimia, binge eating disorder)	19 (45%)
Weight, kg	115.5 ± 15.2
BMI, kg·m^{-2}	41.8 ± 4.6
Elevated blood pressure	17 (40%)
Hypertension	8 (20%)
Obstructive sleep apnea	4 (10%)
Hypertriglyceridemia	4 (10%)
Hypercholesterolemia	1 (2%)
Low HDL cholesterol	17 (40%)
High LDL cholesterol	0 (0%)
NAFLD	27 (64%)
Insulin resistance	16 (40%)
Impaired fasting glucose	2 (5%)
Impaired glucose tolerance	3 (7%)
Diabetes mellitus	0 (0%)
Bone mineral density (total *z* score)	1.2 ± 1.4

Data are expressed as mean ± standard deviation, or as number and associated percentage. BMI = body mass index; HDL = high-density lipoprotein; LDL = low-density lipoprotein; NAFLD = nonalcoholic fatty liver disease.

TABLE 2. Weight loss, comorbidity, mineral and vitamin at 12, 24, and 36 mo after LAGB, compared with inclusion

	Inclusion (N = 42)	M12 (N = 35/42)	*P*	M24 (N = 24/38)	*P*	M36 (N = 16/31)	*P*
Weight, kg	115.5 ± 15.2	100.7 ± 16.4	**<0.001**	99.0 ± 19.4	**<0.001**	95.7 ± 17.1	**0.001**
BMI, kg·m^{-2}	41.8 ± 4.6	36.4 ± 5.8	**<0.001**	35.4 ± 6.2	**<0.001**	34.9 ± 6.1	**<0.001**
%EWL (reference: weight at time of surgery)		30.9 ± 33.1		34.1 ± 38.9		32.9 ± 37.9	
BMI loss % (reference: weight at time of surgery, kg·m^{-2}		4.6 ± 4.0		5.6 ± 6.1		4.6 ± 6.1	
Max %EWL, %		40.5 ± 24.8		44.2 ± 31.7		37.2 ± 34.6	
Max BMI loss, kg·m^{-2}		7.5 ± 4.3		8.8 ± 7.3		7.5 ± 6.0	
Blood pressure			0.784*		0.126*		0.577*
Normal blood pressure	17 (40%)	17 (40%)		7 (41%)		4 (50%)	
Elevated blood pressure	17 (40%)	17 (40%)		9 (53%)		3 (38%)	
Hypertension	8 (20%)	8 (19%)		1 (6%)		1 (13%)	
Hypertriglyceridemia	4 (10%)	1 (3%)	0.371†	0	NA	0	NA
Hypercholesterolemia	1 (2%)	0	NA	0	NA	0	NA
Low HDL cholesterol	17 (40%)	6 (21%)	0.450†	2 (12%)	0.371†	1 (17%)	1†
High LDL cholesterol	0	0	NA	0	NA	0	NA
NAFLD	27 (64%)	10 (33%)	0.121†	4 (21%)	**0.046**†	2 (29%)	1†
Insulin resistance	16 (40%)	5 (17%)	**0.043**†	2 (15%)	0.248†	0	NA
Fasting plasma glucose			0.924*		NA		NA
Normal	34 (95%)	27 (93%)		16 (100%)		7 (100%)	
IFG	2 (5%)	1 (3%)		0		0	
Diabetes mellitus	0	1 (3%)		0		0	
Glucose tolerance			1*		NA		NA
Normal	38 (93%)	28 (97%)		13 (100%)		4 (100%)	
IGT	3 (7%)	1 (3%)		0		0	
Diabetes mellitus	0	0		0		0	
Bone mineral density (total *z* score)	1.2 ± 1.4	0.8 ± 1.2	0.350	0.6 ± 0.9	**0.033**	0.0 ± 1.1	0.809
Bone mineral density (lombal *z* score)	1.1 ± 0.8	0.9 ± 0.9	0.579	0.8 ± 0.8	0.496	−0.5 ± NA	NA
Mineral or vitamin deficiency							
Hypocalcemia	1 (7%)	1 (4%)	NA	0	NA	0	NA
Hypophosphatemia	0	0	NA	0	NA	0	NA
Vitamin D deficiency	27 (90%)	20 (80%)	0.683†	11 (67%)	0.480†	6 (86%)	1†
Iron deficiency	15 (48%)	15 (48%)	0.579†	3 (20%)	0.289†	6 (75%)	1†
Zinc deficiency	3 (10%)	3 (12%)	1†	8 (47%)	0.074†	5 (63%)	0.134†
Magnesium deficiency	6 (19%)	3 (12%)	0.371†	7 (47%)	0.683†	5 (63%)	1†
Vitamin B9 deficiency	3 (50%)	16 (57%)	1†	6 (46%)	1†	5 (71%)	1†
Vitamin B12 deficiency	2 (7%)	1 (4%)	1†	1 (6%)	1†	1 (13%)	1†
Vitamin A deficiency	0	0	NA	0	NA	0	NA
Vitamin B1 deficiency	0	0	NA	0	NA	0	NA
Vitamin E deficiency	0	1 (4%)	NA	0	NA	0	NA

N is the number of patients who attended follow-up divided by the number of patients who should have. %EWL = excess weight loss percentage; BMI = body mass index; BMI loss = %EWL and BMI loss compared with the maximum preoperative weight; HDL = high-density lipoprotein; IFG = impaired fasting glucose; IGT = impaired glucose tolerance; LAGB = laparoscopic adjustable gastric banding; LDL = low-density lipoprotein; Max = %EWL and max; NAFLD = nonalcoholic fatty liver disease; TSC = transferrin saturation coefficient.

Bold indicates significance of P values <0.05.

*Chi-square test.

†McNemar test.

Insulin resistance decreased from 40% at inclusion to 17% at 12 months ($P < 0.05$) and to 15% at 24 months ($P = 0.25$) with regard to inclusion. NAFLD fell from 64% at inclusion to 33% at 12 months ($P = 0.12$) and to 21% at 24 months ($P < 0.05$).

Total *z* score of bone mineral density decreased from 1.2 ± 1.4 Standard Deviation at inclusion to 0.6 ± 0.9 Standard Deviation at 24 months ($P < 0.05$). A total of 76% of the patients had at least 1 mineral or vitamin deficiency during the follow-up, without any statistical difference found between pre- and postoperative assessment.

Thirty-one patients (84%) presented surgical complications during the 24 months after surgery (Supplemental Digital Content Table I, http://links.lww.com/PG9/A100). Nine patients (26%) had class III complications according to the Clavien-Dindo classification: 1 patient presented with a band slippage, 4 patients (11%) had band removal (2 for inefficacy and 2 for vomiting), and 3 had to be operated on again (1 for inflation failures, 1 for chamber repositioning and the last for chamber replacement) within the first 24 months. There was no major complication according to the Clavien-Dindo classification.

Factors Associated With Successful LAGB

Our primary outcome was to identify somatic or psychosocial factors associated with success in LAGB 24 months after surgery in our cohort of adolescents, success being defined by a positive %EWL 24 months after surgery. There were 26 patients (76%) having a positive %EWL at 24 months and 8 (24%) with a negative %EWL at 24 months. Characteristics are described in Table 3.

Having lost weight between inclusion and surgery was associated with a better outcome 24 months after surgery (Odds ratio = 1.16; 95% confidence interval: 1.06-1.32; $P = 0.007$; Table 4). On the contrary, the higher the BMI at surgery, the higher the risk that surgery would fail (Odds ratio = 0.83; 95% confidence interval: 0.70-0.97; $P = 0.033$). No other somatic or psychosocial factors were found to be associated with success at 24 months after LAGB (Table 4).

DISCUSSION

In this cohort of 42 adolescents who underwent a LAGB procedure in a French specialist centre, mean %EWL was 34% at 24 months after surgery. There was no major complication during follow-up, but a high rate of minor complications (84%). Having lost weight before surgery was associated with success, whereas a high BMI at surgery was associated with a higher risk of failure. Comorbidities mostly improved at 24 months after LAGB.

Mean BMI loss was 4.6 $kg{\cdot}m^{-2}$ at 12 months after LAGB, compared with BMI at time of surgery, and 7.5 $kg{\cdot}m^{-2}$ when compared with the maximum preoperative BMI, below the 12 $kg{\cdot}m^{-2}$ expected from the literature (24–26). This difference appeared still present at 24 months with a mean BMI loss of 5.6 $kg{\cdot}m^{-2}$ since surgery and 8.8 $kg{\cdot}m^{-2}$ compared with the maximum preoperative BMI in our cohort.

It may be partly explained by differences between our population and the ones from other studies that seem to present with more severe obesity and associated comorbidities. Indeed, mean BMI at inclusion in our study was 41.8 $kg{\cdot}m^{-2}$, lower than the 45.8 $kg{\cdot}m^{-2}$ reported by Paulus et al (24). Also, 40% of our patients had insulin resistance and none had diabetes mellitus, whereas this meta-analysis described 0%–33% diabetes mellitus and 24%–93% for prediabetes or insulin resistance.

Having lost weight between inclusion and surgery was associated with an increased chance of post-operative sustainable weight loss, in coherence with the study from Sethi et al (14) in adults, who showed that patients with >50 lb of maximum previous weight loss had a significantly higher mean %EWL at 2 years postoperative. On the contrary, having a higher BMI at surgery was associated with an increased risk of failure. However, the present study did not find that other factors associated with success, in particular, factors that may indicate good personal and family eating behavior, such as having completed a weight loss programme before surgery, carefully following a diet and physical activity recommendations or having a family history of obesity or bariatric surgery, were predictive for success in weight loss. This may differ slightly from the study by Khen-Dunlop et al (27) in adolescents, which showed that the number of consultations per year was associated with weight loss. However, verbalization of psychological suffering and emotional eating at inclusion are close to significance (with $P = 0.110$ and $P = 0.085$, respectively) and should be carefully investigated in patients before surgery.

Even if effective weight loss is currently described as a %EWL around 50% at 1 year after bariatric surgery in the literature (28), we choose to define success as having a positive %EWL

TABLE 3. Demographic, psychosocial, and clinical characteristics of patients, according to their positive or negative %EWL at 24 mo

Characteristics	Positive %EWL at 24 mo (n = 26)	Negative %EWL at 24 mo (n = 8)
%EWL at 24 mo	44.0 ± 28.4	−24.0 ± 10.0
Age at baseline, y	15.9 ± 1.2	15.7 ± 1.2
Gender, female	23 (88%)	5 (63%)
Birth weight, kg	3177 ± 458	3030 ± 968
Normal	16 (62%)	6 (75%)
Small for gestational age	2 (8%)	0
Large for gestational age	2 (8%)	2 (25%)
Family history of obesity (first degree)	10 (39%)	1 (13%)
Family history of bariatric surgery (first and second degrees)	5 (19%)	1 (13%)
Individual medical history of psychiatric disorder	13 (50%)	4 (50%)
Family history of psychiatric disorder (first degree)	8 (31%)	3 (38%)
Declared age by parents of weight gain	4.6 ± 3.5	4.1 ± 3.0
Declared triggering event	18 (69%)	6 (75%)
Timeframe between perceived weight problem and care	8.7 ± 4.0	9.8 ± 4.0
Adolescent requesting surgery	23 (89%)	6 (75%)
Family adversities (divorce, death or absence of a parent, sick parent, unfulfilled emotional needs, mistreatment, sexual abuse, or child welfare procedures)	17 (65%)	6 (75%)
School difficulties (grade repetition, school dropout, integration classes, specialist teaching, medico-pedagogic institute, or distance learning)	7 (27%)	1 (13%)
Verbalization of psychological suffering	23 (89%)	5 (63%)
Emotional eating (boredom, loneliness, pleasure, anger, sadness, stress, or comfort)	16 (62%)	2 (25%)
Eating disorders (anorexia nervosa, bulimia, binge eating disorder)	12 (46%)	2 (25%)
Time between baseline and surgery, y	1.0 ± 0.5	1.29 ± 0.46
Weight loss programme in the 2 y prior surgery	12 (46%)	2 (25%)
Weight difference between baseline and surgery, kg	−5.8 ± 10.6	10.3 ± 8.1
BMI at surgery, kg/m^2	39.8 ± 5.1	44.9 ± 5.1
Compliance with diet recommendations (≥3 meals a day) at 12 mo	17 (65%)	6 (75%)
Compliance with physical activity recommendations (≥200 min per week) at 12 mo	10 (39%)	2 (25%)
Food intolerance requiring deflation of the LAGB	5 (19%)	1 (13%)
Reoperation on LAGB other than removal	0	3 (38%)

%EWL = excess weight loss percentage; BMI = body mass index; LAGB = laparoscopic adjustable gastric banding.

TABLE 4. Factors associated with success at 24 mo after LAGB, defined as a positive %EWL

Characteristics	OR	P
Age at baseline, y	1.18 [0.58; 2.45]	0.651
Gender (female)	0.22 [0.03; 1.46]	0.110
Birth weight		
Normal		
Small for gestational age	0.00	0.995
Large for gestational age	0.38 [0.04; 3.70]	0.376
Family history of obesity (first degree)	0.00	0.997
Family history of bariatric surgery (first and second degrees)	2.5 [0.07; 90.34]	0.577
Father's socioprofessional category	-	0.279
Mother's socioprofessional category	-	0.091
Individual medical history of psychiatric disorder	1.00 [0.20; 5.08]	1
Family history of psychiatric disorder (first degree)	0.74 [0.14; 4.32]	0.722
Declared age by parents of weight gain	1.05 [0.82; 1.42]	0.730
Declared triggering event	0.38 [0.02; 2.73]	0.398
Timeframe between perceived weight problem and treatment	0.93 [0.73; 1.14]	0.516
Adolescent claiming surgery	2.56 [0.29; 19.21]	0.358
Family adversities (divorce, death or absence of a parent, sick parent, unfulfilled emotional needs, mistreatment, sexual abuse, or child welfare procedures)	0.63 [0.08; 3.42]	0.613
School difficulties (grade repetition, school dropout, integration classes, specialist teaching, medico-pedagogic institute, or distance learning)	2.59 [0.36; 52.73]	0.412
Verbalization of psychological suffering	4.60 [0.68; 32.46]	0.110
Emotional eating (boredom, loneliness, pleasure, anger, sadness, stress, or comfort)	4.80 [0.90; 37.43]	0.085
Eating disorders (anorexia nervosa, bulimia, binge eating disorder, hyperphagia)	2.57 [0.48; 19.86]	0.297
Time between baseline and surgery above the median value	0.28 [0.04; 1.55]	0.157
Weight loss programme in the 2 y prior surgery	2.20 [0.41; 17.01]	0.297
Weight loss between baseline and surgery, kg	**1.16 [1.06; 1.32]**	**0.007**
BMI at surgery, kg/m^2	**0.83 [0.70; 0.97]**	**0.033**
Compliance with diet recommendations (≥3 meals a day) at 12 mo	1.42 [0.06; 17.66]	0.791
Compliance with physical activity recommendations (≥200 min per week) at 12 mo	2.78 [0.47; 22.97]	0.284
Food intolerance requiring deflation of the LAGB	1.67 [0.22; 34.81]	0.665

%EWL = excess weight loss percentage; BMI = body mass index; LAGB = laparoscopic adjustable gastric banding; OR = odds ratio.
Bold indicate significant OR in table.

at 24 months. In our cohort, the mean %EWL was 44.0 ± 28.4 at 24 months in patients having a positive %EWL, compared with −24.0 ± 10.0 in patients having a negative %EWL. We made this choice because it seemed to us that the real failure of the programme was the absence of weight loss and that losing weight, without particular %EWL level requirement, provided either physical or psychological benefits to our patients. Indeed, our cohort presented a high rate of comorbidities resolution, with in particular a important decrease in insulin resistance and NAFLD. Concerning the other comorbidities, even if no statistical difference was found, there were no longer patients with hypertriglyceridemia and hypercholesterolemia at 24 months, low HDL cholesterol rates decreased from 40% to 17%, and no patients showed impairment in glucose metabolism anymore.

Our cohort had a high rate of minor complications at 24 months of surgery. In particular, 65% of the patients experienced some degree of food intolerance, much more than the 9.9% of patients having gastrointestinal symptoms reported by Paulus et al (24), even if for our patients, dysphagia was mainly transient and linked to bad food intake habits. Among them, only 16% needed deflation of the surgical device, the other ones recovering with tips on "how to eat well with a band." The number of patients needing reinterventions were similar in our study and in Paulus' review, with respectively 19% and 14.7% of patients (24). No deaths or major complications were observed during follow-up, which is far below the rate of complications for other bariatric surgeries (24), in particular fewer readmissions and reoperations than gastric bypass at 1 year postsurgery, according to Messiah et al (29) in 2013.

Interestingly, bone mineral density significantly decreased between inclusion and 24 months after surgery. However, the body fat percentage is known to have a deleterious effect on bone acquisition in children and adolescents (30). Also, 76% of our patients had at least one mineral or vitamin deficiency during the follow-up and 57% of our patients needed at least one period of supplementation, whereas Paulus et al (24) reported deficiencies only in 0.5%–36% of patients. 67% of our cohort presented a vitamin D deficiency at 24 months after surgery, compared with 90% at inclusion, this high rate being similar to the 94% encountered in the general population of adolescent girls with vitamin D deficiency in France (31). The other most common deficiencies identified were vitamin B9 (57%) and iron (48%) at 12 months, and magnesium and zinc (47%) at 24 months after surgery, which increased from 10% and 19% at inclusion, respectively. These high rates of vitamin deficiencies may be explained by a lack of systematic supplementation after surgery in our cohort and justify ensuring regular follow-up to be punctually supplemented.

One major limitation of this study is the small number of patients of our cohort, which can impact our statistical analysis. Another limitation is the high rate of patients lost to follow-up at 24 months (37%), which is common in cohort studies, and of particular concern among bariatric surgery cohorts (24). One of the explanations can be found in the fact that the patients operated on in our establishment were recruited from a large territory. For some families, this meant long travel times, and they asked to be followed up closer to home once the operation had been performed and the patient stabilized. Moreover, this is a pediatric cohort, and some patients were considered as lost to follow-up because, 2 years after surgery, they had reached their majority and had been referred to adult bariatric surgery teams. Finally, the management of adolescent with obesity has evolved considerably recently, both in terms of medical and surgical treatment, particularly with the advent of glucagon-like peptide 1 analogs, which suggests that our results cannot be compared with future cohorts. However, this is a prospective study, with standardized follow-up throughout the study, which ensures a certain homogeneity. Finally, our study may be limited by the self-report modality of a few measured factors, such as psychosocial ones at inclusion, or compliance with physical activity and dietary recommendations during follow-up.

In conclusion, in our cohort of adolescents with severe obesity treated by LAGB in our specialist centre, 76% of our patients had lost weight 24 months after surgery, with a mean %EWL of 34.1%. Comorbidities mainly reduced after LAGB and no major complications occurred during the follow-up. Having lost weight before surgery was associated with successful surgery, whereas a high BMI at surgery increases the risk of failure.

REFERENCES

1. Castetbon K. Recent prevalence of child and adolescent overweight and obesity in France and abroad. *Arch Pediatr*. 2015;22:111–115.
2. Kumar S, Kelly AS. Review of childhood obesity: from epidemiology, etiology, and comorbidities to clinical assessment and treatment. *Mayo Clin Proc*. 2017;92:251–265.
3. Twig G, Yaniv G, Levine H, et al. Body-mass index in 2.3 million adolescents and cardiovascular death in adulthood. *N Engl J Med*. 2016;374:2430–2440.
4. Kobes A, Kretschmer T, Timmerman G, et al. Interventions aimed at preventing and reducing overweight/obesity among children and adolescents: a meta-synthesis. *Obes Rev*. 2018;19:1065–1079.
5. Mead E, Atkinson G, Richter B, et al. Drug interventions for the treatment of obesity in children and adolescents. *Cochrane Database Syst Rev*. 2016;11:CD012436.
6. Ells LJ, Mead E, Atkinson G, et al. Surgery for the treatment of obesity in children and adolescents. *Cochrane Database Syst Rev*. 2015;6:CD011740.
7. Rajjo T, Mohammed K, Alsawas M, et al. Treatment of pediatric obesity: an umbrella systematic review. *J Clin Endocrinol Metab*. 2017;102:763–775.
8. Haute Autorité de Santé. Définition des critères de réalisation des interventions de chirurgie bariatrique chez les moins de 18 ans. 2016 janv.
9. Oberlin P, De Peretti C. *Chirurgie de l'obésité: 20 fois plus d'interventions depuis 1997*. Études Résultats Dir Rech Études Lévaluation Stat DRESS. févr 2018.
10. Schmitt F, Riquin E, Beaumesnil M, et al. Laparoscopic adjustable gastric banding in adolescents: Results at two years including psychosocial aspects. *J Pediatr Surg*2016;51:403–408.
11. Schouten R, van 't Hof G, Feskens PB. Is there a relation between number of adjustments and results after gastric banding?. *Surg Obes Relat Dis*. 2013;9:908–912.
12. Sarwer DB, Wadden TA, Moore RH, et al. Preoperative eating behavior, postoperative dietary adherence, and weight loss after gastric bypass surgery. *Surg Obes Relat Dis*. 2008;4:640–646.
13. Shen R, Dugay G, Rajaram K, et al. Impact of patient follow-up on weight loss after bariatric surgery. *Obes Surg*. 2004;14:514–519.
14. Sethi M, Beitner M, Magrath M, et al. Previous weight loss as a predictor of weight loss outcomes after laparoscopic adjustable gastric banding. *Surg Endosc*. 2016;30:1771–1777.
15. van Strien T. Causes of emotional eating and matched treatment of obesity. *Curr Diab Rep*. 2018;18:35.
16. American Psychiatric Association. *Diagnostic and statistical manual of mental disorders*. 5th ed. [Internet]. 2013. Disponible sur.
17. Brethauer SA, Kim J, el Chaar M, et al. Standardized outcomes reporting in metabolic and bariatric surgery. *Surg Obes Relat Dis*. 2015;11:489–506.
18. Flynn JT, Kaelber DC, Baker-Smith CM, et al. Clinical practice guideline for screening and management of high blood pressure in children and adolescents. *Pediatrics*. 2017;140:e20171904.
19. Andersen IG, Holm J-C, Homøe P. Obstructive sleep apnea in obese children and adolescents, treatment methods and outcome of treatment - a systematic review. *Int J Pediatr Otorhinolaryngol*. 2016;87:190–197.
20. Mellerio H, Alberti C, Druet C, et al. Novel modeling of reference values of cardiovascular risk factors in children aged 7 to 20 years. *Pediatrics*. 2012;129:e1020–e1029.
21. Huang JS, Barlow SE, Quiros-Tejeira RE, et al. Childhood obesity for pediatric gastroenterologists. *J Pediatr Gastroenterol Nutr*. 2013;56:99–109.
22. Mayer-Davis EJ, Kahkoska AR, Jefferies C, et al. ISPAD Clinical Practice Consensus Guidelines 2018: Definition, epidemiology, and classification of diabetes in children and adolescents. *Pediatr Diabetes*. 2018;19(suppl 27):7–19.
23. Dindo D, Demartines N, Clavien P-A. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg*. 2004;240:205–213.
24. Paulus GF, de Vaan LEG, Verdam FJ, et al. Bariatric surgery in morbidly obese adolescents: a systematic review and meta-analysis. *Obes Surg*. 2015;25:860–878.
25. O'Brien PE, Sawyer SM, Laurie C, et al. Laparoscopic adjustable gastric banding in severely obese adolescents: a randomized trial. *JAMA*. 2010;303:519–526.
26. Ruiz-Cota P, Bacardí-Gascón M, Jiménez-Cruz A. Long-term outcomes of metabolic and bariatric surgery in adolescents with severe obesity with a follow-up of at least 5 years: a systematic review. *Surg Obes Relat Dis*. 2019;15:133–144.
27. Khen-Dunlop N, Dabbas M, De Filippo G, et al. Primordial influence of post-operative compliance on weight loss after adolescent laparoscopic adjustable gastric banding. *Obes Surg*. 2016;26:98–104.
28. Sarno LA, Lipshultz SE, Harmon C, et al. Short- and long-term safety and efficacy of bariatric surgery for severely obese adolescents: a narrative review. *Pediatr Res*. 2019;87:202–209.
29. Messiah SE, Lopez-Mitnik G, Winegar D, et al. Changes in weight and co-morbidities among adolescents undergoing bariatric surgery: 1-year results from the Bariatric Outcomes Longitudinal Database. *Surg Obes Relat Dis*. 2013;9:503–513.
30. Deng K-L, Yang W-Y, Hou J-L, et al. Association between body composition and bone mineral density in children and adolescents: a systematic review and meta-analysis. *Int J Environ Res Public Health*. 2021;18:12126.
31. Esterle L, Nguyen M, Walrant-Debray O, et al. Adverse interaction of low-calcium diet and low 25(OH)D levels on lumbar spine mineralization in late-pubertal girls. *J Bone Miner Res*. 2010;25:2392–2398.