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BRIEF COMMUNICATION

Medium- to Long-Term Outcomes of Gastric Banding in Adolescents: a Single-Center Study of 97 Consecutive Patients

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Abstract Morbid obesity in adolescents has been treated effectively with laparoscopic adjustable gastric banding (LAGB). We prospectively studied 97 consecutive obese adolescents undergoing LAGB over the course of 10 years. The average patient age at surgery was 17.2 ± 0.7 years; mean body mass index, 44.9 ± 6.1 kg/m^2. Excluding those lost to follow-up (n = 21), respective mean total weight loss and excess weight loss were 20.0 ± 16.6 and 46.6 ± 39.5% (n = 76, 78.4%). An ascending trend line showed a significant positive correlation between excess weight loss and follow-up duration (mean 56.0 ± 22.0 months). There was no mortality or morbidity. Nineteen patients (25.0%) underwent band removal at a mean 43.0 ± 28.0 months. LAGB proved safe and effective over the mid- and longer term; it should be strongly considered as a procedure of first intention for obese adolescents.

Keywords Bariatric surgery · Laparoscopic adjustable gastric banding · LAGB · Banding · Adolescents

Introduction

Adolescent obesity is a growing global pandemic for which evidence-based, targeted interventions are needed [1]. The prevalence of adolescent obesity in the USA between 2011 and 2014 was estimated at 17.0% among youths aged 2–19 years old [2]. Evidence suggests that the number of years lived with obesity ("obesity-years") is directly related to the risk of death from cardiovascular disease and cancer [3]; therefore, unsuccessfully addressed obesity that begins in youth adds risk to this population. Pediatric morbid obesity that remains unsuccessfully treated into adulthood carries an increased health risk due to additional obesity-years. Medical treatment of adolescent obesity results in only modest weight reduction that is not well maintained [4]. Short-term studies of bariatric surgery in adolescents demonstrate significant sustained weight loss, comorbidity resolution, and improvement in quality of life [5].

The few mid- to long-term (> 5-year follow-up) studies of bariatric surgery in adolescents report that the greatest weight loss was achieved in the initial 3 postoperative years, with the majority of complications occurring after that time [6–11]. Nijhawan et al. (2012 [6]), Sugerman et al. (2003 [7]), and Strauss et al. (2001 [8]) each described long-term results of Roux-en-Y gastric bypass (RYGB) in adolescents, reporting reductions in mean body mass index (BMI, kg/m^2) of 17.1 (85.8 months), 19.0 (60.0 months), and 16.2 (68.8 months), respectively. Inge et al., in their 2017 prospective analysis of adolescent bariatric surgery at 5 plus years (the "FABS-5+" follow-up study, 2016), showed that patients undergoing RYGB achieved a long-term benefit (BMI reduction of 16.9 at mean follow-up of 96 months) that outweighed the risks of undergoing bariatric surgery at a young age (e.g., micronutrient deficiencies; additional gastrointestinal procedures) [9]. A single-center study by Silberhumer et al. (2011) described a reduction in BMI of 17.9 after laparoscopic adjustable gastric banding (LAGB) at 60-month follow-up [10]. A recent single-center study by Paulus et al. (2016) reported that 60.0% of adolescents achieved weight-loss success (BMI reduction, 10.7) with LAGB without major adverse events at a median follow-up of 64 months [11].

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LAGB is a safe restrictive procedure that has been used successfully as a treatment for morbid obesity in adolescents in the short and medium terms. The operation is reversible and can facilitate a second procedure in case of long-term band intolerance or failure [12]. As adolescents are typically less psychologically mature than adult patients and young patients may later regret decisions undertaken on their behalf in a family setting, surgical procedures used in adolescents should not be irreversible. There is no evidence that suggests that bariatric surgery in adolescents is safe, effective, and improves quality of life at a long-term follow-up of 10 years. Our aim was to contribute to the mid- to long-term evidence regarding morbidly obese adolescents undergoing LAGB in a consecutive patient series followed over the course of 10 years.

Methods

Study Design and Inclusion

This investigation was a retrospective single-center, observational study in an officially authorized European Specialized Center of Obesity (SCO). Consecutively, presenting adolescents were eligible for inclusion in the LAGB study if they had achieved their full growth and sexual maturity, and had undergone a medical nutritional and dietary management program for at least 1 year that concluded in failure.

Criteria for surgery in the adolescent patients were the same as those applied to adults in consideration for bariatric surgery: i.e., BMI ≥ 40.0, or a BMI of 35.0–40.0 including comorbidities. The final decision to operate was taken after two staff meeting discussions, one at the study inclusion time point, and the second, at the end of the preoperative preparation.

Pre-surgical

The care team including a nutritionist physician, dietitian, psychiatrist, psychologist, endocrinologist, and surgeon(s) participated in the assessment and long-term care of the patients. Systematic evaluation of obesity-related comorbidities (dyslipidemia, type 2 diabetes mellitus (T2DM), hypertension, sleep apnea syndrome [SAS]) was performed, as well as etiological and endocrine assessments. Preoperative tests included a blood test (dyslipidemia, T2DM), blood pressure measurement, spirometry in case of dyspnea or if the Epworth sleeping test suggests a SAS, and an abdominal ultrasound scan and gastroscopy in every patient. Articular X-rays were performed on suspicion of coxa vara (Blount's disease) and early osteoarthritis in order to make an objective diagnosis in the case of a patient with a BMI of 30–35 kg/m^2 and no other objective comorbidity. Comorbidity resolution was defined as normalized blood tests and no further treatment needed for dyslipidemia and T2DM, normalized blood pressure for hypertension, no need for night respiratory support, and no more articular pain.

Procedure and Follow-up

The LAGB procedure was performed using the pars flaccida technique. MID-2 and then MID-100 M rings (since 12/07/13; MID, Lyon, France) were implanted without suturing the stomach. Since early 2013, the operations were completed in the context of single-day surgery. Patients were discharged in the evening if conditions permitted. A first filling of the band was performed under fluoroscopy 2 months after surgery. After 4 months, all patients underwent their first postoperative examination, including same-day consultation with the full care team. Filling of the band was performed gradually every 6–12 months in accord with weight loss and patient tolerance. The routine interval of the follow-up is at least one consultation a year, when a fine adjustment of the band is reached. As obesity is a chronic disease, patients require life-long follow-up. We focused on achieving a balance between progressive weight loss and food tolerance. Nutritional education was reinforced during each visit. With respect to nutrition, there was no surgical regimen: Patients were only required to swallow well-chewed food and avoid drinking while eating. Every patient was contacted by phone call and surveyed using the Bariatric Analysis and Reporting Outcome System (BAROS), which was extrapolated to teenagers in the absence of a specific published test [13].

Statistical Analysis

Continuous data were presented using means, standard deviations, ranges, and/or 95% confidence intervals (CIs); categorical data were presented using frequencies and percentages. Within-group changes in continuous variables were analyzed with paired samples *t* tests. LAGB survival probabilities were estimated using standard Kaplan-Meier methods. Pearson's correlation coefficient was used to assess relationship between continuous variables. Statistical significance was set at $p < 0.05$; all statistical tests were two tailed. Analyses were performed using SPSS software (version 20; IBM, Chicago, IL).

Results

From March 2006 to November 2015, 97 teenagers (79 females, 18 males) underwent LAGB. Average age at initial consultation was 16.6 ± 1.2 years (range 11.0–17.0); and, at the time of surgery, 17.2 ± 0.7 years (15.0–18.0) (Table 1). Mean BMI at surgery was 44.9 ± 6.1 kg/m^2 (35.9–74.4). Mean operative time was 20.5 ± 5.2 min. Beginning in early

Table 1 Preoperative characteristics of adolescent patients undergoing LAGB

Characteristic	Mean ± SD (range) $n = 97$
Age at initial consultation (years)	16.6 ± 1.2 (11.0–17.0)
Age at surgery (years)	17.2 ± 0.7 (15.0–18.0)
Height (cm)	166.2 ± 7.4 (150.0–183.0)
Absolute weight (kg)	124.4 ± 22.5 (96.0–240.0)
Body mass index (kg/m^2)	44.9 ± 6.1 (35.9–74.4)
	n (%)
Male	18 (18.6)
Female	79 (81.4)
Articular complications	67 (69.1)
Hypertension	8 (8.3)
Type 2 diabetes mellitus	1 (1.0)
Dyslipidemia	14 (14.4)
Asthma	7 (7.2)
Sleep apnea	5 (5.2)

2013, 23 patients were discharged on the evening of the day of surgery.

Twenty-one patients (21.6%) were lost to follow-up (LTFU). LTFU patients had no contact with our center for more than 1 year in spite of at least two phone calls to them from our center. Mean follow-up time was 56.0 ± 22.0 months (4.0–120.0). There were no cases of postoperative mortality or morbidity, and no conversions to laparotomy. The gastric band was removed in 19 of 76 patients (25.0%) within an average time of 43.0 ± 28.0 months. A Kaplan-Meier survival curve is presented in Fig. 1; LAGB-estimated survival probabilities at 5 and 10 years were 0.8 and 0.6, respectively. Band removal etiologies were slippage (n = 9, 11.8%), intolerance (n = 9, 11.8%), and band leak (n = 1, 1.3%) within average times of 24.0 ± 16.0 months, 57.0 ± 27.0 months, and 75.0 months, respectively. Eighteen patients undergoing band removal elected to have a second bariatric procedure: RYGB (n = 6, 7.9%), LSG (n = 5, 6.6%), or a second LAGB (n = 7, 9.2%; censored in the survival curve after the first band removal).

A second LAGB was proposed and performed if the patient had accidental slippage. Intolerance phenomenon (gastro-esophageal reflux and vomiting despite band loosening) is the consequence of an esophageal dilation upstream of the band. This could be delayed by improving nutritional education. Adolescents must be involved in their own healthcare management to optimize band effectiveness and reduce the likelihood of band failure and removal. Band fixation was recently shown to be preventive of band slippage [14]. We consider morbid obesity a chronic disease, and every patient is at risk of requiring a second procedure. The morbidity rate of a second procedure increased when the band had a gastric fixation.

Excluding LTFU patients, mean absolute weight loss in the 76 adolescents undergoing LAGB with complete follow-up was 24.9 kg (95% CI 19.8, 30.0), with a mean BMI reduction

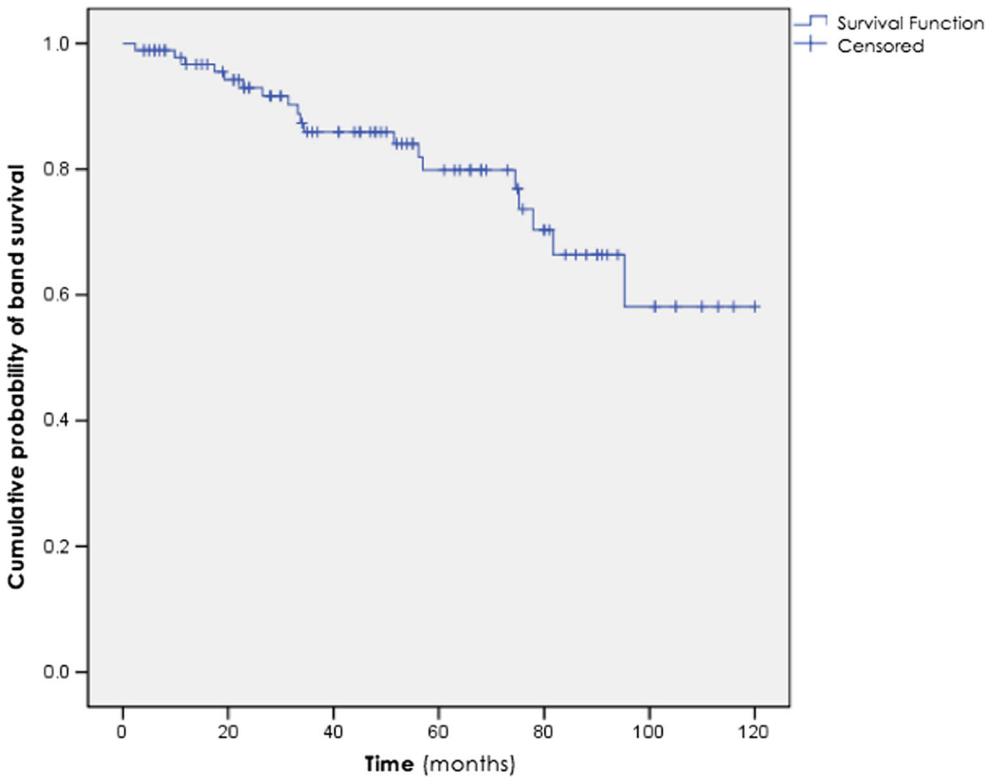

Fig. 1 Gastric band Kaplan-Meier survival curve

Table 2 Weight loss in adolescents following LAGB

Variable	Baseline mean ± SD	Follow-up mean ± SD	Change mean ± SD (95% CI)	*p* value*
Absolute weight (kg)	121.2 ± 19.9	96.3 ± 21.6	24.9 ± 22.4 (19.8, 30.0)	< 0.001
Body mass index (kg/m^2)	44.2 ± 5.3	35.2 ± 7.5	9.0 ± 7.8 (7.2, 10.8)	< 0.001
Overall excess wt loss (%) (95% CI)		46.6 ± 39.5 (37.7, 55.5)		
Overall total wt loss (%) (95% CI)		20.0 ± 16.6 (16.1, 23.7)		

*Paired samples *t* test

of 9.0 kg/m^2 (7.2, 10.8) (Table 2). Corresponding mean EWL and mean TWL values were 46.6% (37.7, 55.5) and 20.0 (16.1, 23.7), respectively. An ascending trend line showed an overall significant positive correlation (r = 0.42, p < 0.001) between EWL and follow-up duration (Fig. 2).

More than 68.0% of adolescent LAGB patients experienced improvement in comorbidities. The resolution rate for articular problems was 75.0% (30/40, LTFU: n = 27). Asthma resolution rate was 100.0% (4/4, LTFU: n = 3); 50.0% for SAS (1/2, LTFU: n = 3); 100.0% for hypertension (3/3, LTFU: n = 5); 100.0% for T2DM (1/1); and 14.0% for dyslipidemia (1/7, LTFU: n = 7). One patient had bilateral coxa vara surgery; one patient had recurrent idiopathic intracranial hypertension. Among females, one had persistent secondary amenorrhea and two had polycystic ovary syndrome. Sixteen patients had pregnancies with the band intact with no complication related to vitamin deficiency.

Satisfaction surveys were conducted by phone call and completed by 60.0% of patients. The mean satisfaction rating for the LAGB procedure was 7.1 ± 2.2/10 points. In addition, more than 80.0% of patients reported that they would be willing to repeat the same LAGB-based treatment for their obesity. Finally, the overall patient mean BAROS score was 3.2 ± 2.2/9 points, which represents a "good" overall LAGB outcome classification. Ongoing follow-up, wherein all patients in the series have passed through the 5-year and longer-term time points, will provide a more accurate determination of the benefit of LAGB in adolescents.

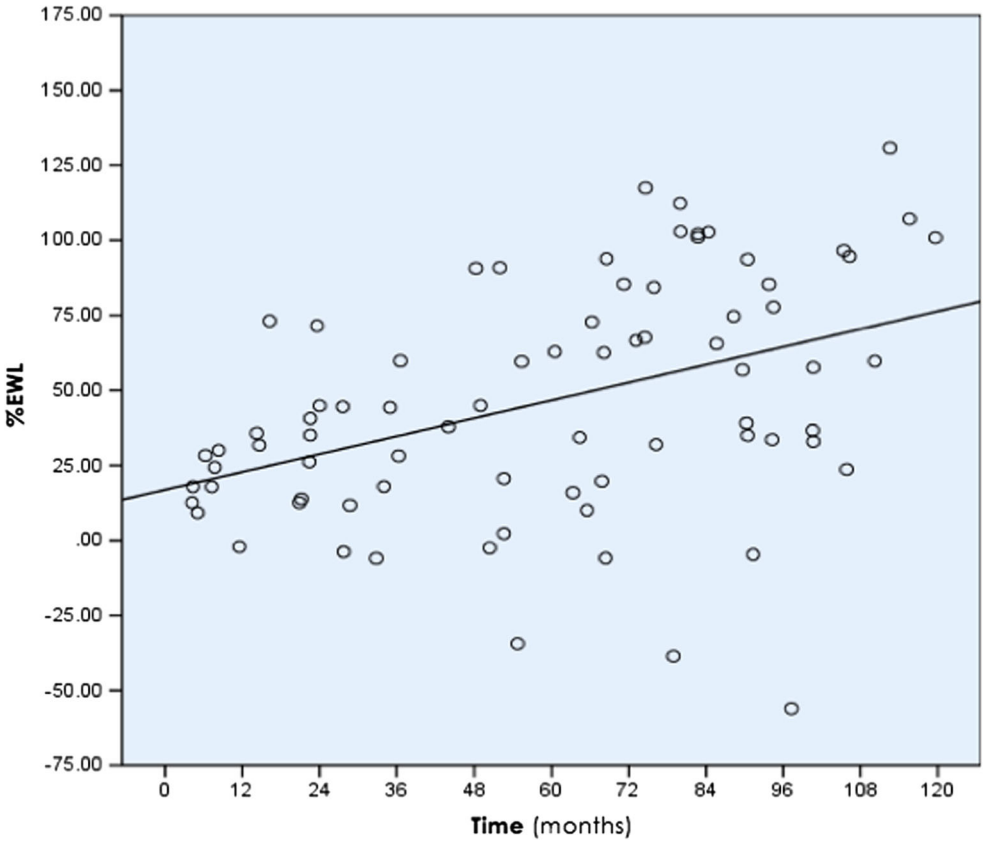

Fig. 2 Correlation between excess weight loss and follow-up duration. Each dot represents a unique patient (intention to treat analysis)

Conclusion

The effectiveness of LAGB appears to improve over the long term in adolescents. LAGB is a reliable, reversible technique that may be an appropriate and ethical first-line surgical option for obese youth. In the current study of adolescents undergoing LAGB, the procedure was safe and there was a significant positive correlation between excess weight loss and follow-up duration (mean 56.0 ± 22.0 months); overall excess weight loss was 46.6%.

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Compliance with Ethical Standards

Informed Consent Informed consent was obtained from all participants.

Human and Animal Rights The study was performed in accord with the ethical standards of the Declaration of Helsinki.

Conflict of Interest Author 5 is a consultant for MID, Lyon, France. Author 1, author 2, author 3, and author 4 have no conflict of interest.

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