Trends and Outcomes of Adolescent Bariatric Surgery in California, 2005–2007

WHAT'S KNOWN ON THIS SUBJECT: There has been a dramatic increase in the use of adolescent bariatric surgery. However, previous studies were unable to distinguish laparoscopic versus open procedures. Furthermore, the use of laparoscopic adjustable gastric banding (LAGB) has not been studied on a population level.

WHAT THIS STUDY ADDS: The rate of LAGB increased sevenfold from 2005 to 2007 with a corresponding decrease in the rate of laparoscopic Roux-en-Y gastric bypass. Furthermore, white adolescents represented only 28% of those who were overweight but accounted for 65% of the procedures.

abstract

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OBJECTIVE: The goal of this study was to evaluate trends, and outcomes of adolescents who undergo bariatric surgery.

PATIENTS AND METHODS: Patients younger than 21 years who underwent elective bariatric surgery between 2005 and 2007 were identified from the California Office of Statewide Health Planning and Development database. Multivariate logistic regression was used to identify factors associated with the type of surgery.

RESULTS: Overall, 590 adolescents (aged 13–20 years) underwent bariatric surgery in 86 hospitals. White adolescents represented 28% of those who were overweight but accounted for 65% of the procedures. Rates of laparoscopic adjustable gastric banding (LAGB) increased 6.9-fold from 0.3 to 1.5 per 100 000 population ($P < .01$), whereas laparoscopic Roux-en-Y gastric bypass (LRYGB) rates decreased from 3.8 to 2.7 per 100 000 population ($P < .01$). Self-payers were more likely to undergo LAGB (relative risk [RR]: 3.51 [95% confidence interval: 2.11–5.32]) and less likely to undergo LRYGB (RR: 0.45 [95% confidence interval: 0.33–0.58]) compared with privately insured adolescents. The rate of major in-hospital complication was 1%, and no deaths were reported. Of the patients who received LAGB, 4.7% had band revision/removal. In contrast, 2.9% of those who received LRYGB required reoperations.

CONCLUSIONS: White adolescent girls disproportionately underwent bariatric surgery. Although LAGB has not been approved by the US Food and Drug Administration for use in children, its use has increased dramatically. There was a complication rate and no deaths. Long-term studies are needed to fully assess the efficacy, safety, and health care costs of these procedures in adolescents. *Pediatrics* 2010;126: e746–e753

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KEY WORDS

bariatric surgery, gastric bypass, morbid obesity, weight loss, adolescent, child, outcome assessment, health resources

ABBREVIATIONS

LRYGB—laparoscopic Roux-en-Y gastric bypass
LAGB—laparoscopic adjustable gastric banding
OSHPD—Office of Statewide Health Planning and Development
ED—emergency department
ASC—ambulatory surgery center
ICD-9-CM—*International Classification of Diseases, Ninth Edition, Clinical Modification*
CPT—*Current Procedural Terminology*
RR—relative risk

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Obesity is one of the most common and important health problems facing children and our society today. Childhood obesity is associated with diabetes,[1,2] coronary artery disease,[3] fatty liver disease,[4] premature mortality in adulthood,[5] and a decreased quality of life.[6] Nearly 90% of children with a BMI at >99th percentile become obese adults[7] and develop the comorbidities of adult obesity.

Surgery is currently the most effective method for achieving significant long-term weight loss in severely obese patients (BMI ≥ 40 or BMI >35 with obesity-related comorbidity). In adolescents, laparoscopic Roux-en-Y gastric bypass (LRYGB) can result in significant weight loss, reduction in comorbidities, and improvement in quality of life.[8–12] Laparoscopic adjustable gastric banding (LAGB) has not been approved by the US Food and Drug Administration for patients younger than 18 years. Although early results with LAGB have indicated that it is safe and effective,[13–16] long-term outcomes have not yet been reported for adolescents.

The most recent studies on trends in the use of adolescent bariatric surgery examined data through 2003.[17,18] Since that time, the landscape of bariatric surgery in the United States has changed dramatically because of the increasing use of LAGB in adults. It is unclear if this is also the trend in adolescent bariatric surgery. Furthermore, studies in the adult population have revealed socioeconomic disparities in access to bariatric surgery.[19–21] Our objective was to study the current trends and disparities in access to bariatric surgery for adolescents, to identify factors that affect procedural choice, and to characterize in-hospital and postdischarge complications.

METHODS

Estimates of Overweight Prevalence in California

The prevalence of adolescent overweight (≥85th percentile) in California was estimated by combining data from the US Census Bureau and the California Health Interview Survey (CHIS). The US Census Bureau publishes state population projections based on previous census data. The projected number of adolescents according to race in California from 2005 to 2007 was used.[22] The CHIS is a population-based telephone survey of California's population conducted every other year since 2001.[23] It is the largest health survey conducted in any state and one of the largest health surveys in the nation. Ahn el al[24] used the 2003 CHIS to obtain the percentage of overweight among adolescents in California according to race. We used the projected number of adolescents in California from the US Census Bureau and the percentage of overweight adolescents according to race in California from Ahn et al to calculate the prevalence of overweight adolescents in California.

Data Source and Linkage

This retrospective population cohort study was performed after obtaining institutional review board approval from both the University of California Los Angeles and the Office of Statewide Health Planning Development (OSHPD) in California. Three OSHPD databases were used: (1) patient discharge database; (2) emergency department (ED) database; and (3) ambulatory surgery center (ASC) database. The databases were linked to capture the rates of procedures and outcomes in hospitals, EDs, and ASCs for adolescents undergoing bariatric surgery. These OSHPD databases collect semiannual data from all inpatients discharged from nonfederal hospitals, visits to EDs, and encounters at freestanding or hospital-based ACSs licensed in the state of California. Each record captures 1 encounter and includes patient demographics, a facility identification code, dates of service, and codes for diagnoses and procedures during that encounter.[25,26] All diagnosis and procedure codes are categorized according to the *International Classification of Diseases, Ninth Edition, Clinical Modification* (ICD-9-CM) coding scheme or according to the *Current Procedural Terminology* (CPT) coding scheme. The OSHPD internally validates individual records in the OSHPD databases through 9 levels of checkpoints with an error tolerance level of <2%.[27] Individual records were flagged and reviewed if they contained illogical or erroneous relationships between ICD-9-CM and CPT diagnosis and procedure codes. A unique deidentified patient record number was used to confidentially link separate encounters at different times and different hospital settings from these 3 different databases to each individual patient. This database has been used previously to examine health outcomes in both adult and pediatric populations.[28–32]

Patient Selection

Patients younger than 21 years who underwent bariatric surgery between 2005 and 2007 were extracted from the patient discharge database for inpatient bariatric surgeries and ASCs database for outpatient bariatric surgeries. We selected the younger-than-21-years age group because it is the population seen in many adolescent bariatric centers (including our own UCLA Fit for Healthy Weight Program). Furthermore, this is the age group defined by the California Children's Services for potential coverage.

Inclusion criteria included elective cases of patients with a procedure code for an inpatient or outpatient bariatric proce-

dure. In addition, a diagnosis code for obesity (ICD-9 278.0, 278.00, or 278.01) was required to exclude patients who underwent gastric procedures for indications other than morbid obesity or its associated comorbidities. The bariatric surgical procedures were grouped by codes into 3 categories: LRYGB, LAGB, and other bariatric procedures such as open Roux-en-Y gastric bypass, vertical-banded gastroplasty, and other restrictive gastric procedures (Table 1). To evaluate off-label use of LAGB, we performed a subgroup analysis of patients younger than 18 years.

The patients came from 86 of 835 licensed California hospitals and ASCs. Center volumes were divided into quartiles, and the top (>8 cases per year) and bottom (<2 cases per year) quartile hospitals were labeled as "high-volume" and "low-volume" centers accordingly. An institution was considered a "bariatric center of excellence" if it had this designation from either the American College of Surgeons or the American Society for Metabolic and Bariatric Surgery.[33,34] Children's hospitals were defined as freestanding children's hospitals as designated by the National Association of Children's Hospitals and Related Institutions criteria.[35] Distance traveled was calculated from the patient's resident zip code to the place of surgery.

Outcomes Measured

The first encounter that contained the bariatric procedure code was identified as the index procedure. Subsequent in-hospital complications, postoperative readmissions, ED visits, and ASC encounters were tracked for individual adolescents through a unique deidentified patient record number provided by the OSHPD. ACS visits consisted of outpatient revision and removal of bands, as well as esophagoscopy and dilation for dysphagia etc. The mortality rate was also tracked between 2005 and 2007.

TABLE 1 ICD-9-CM and CPT Procedure Codes Used to Determine Surgical Procedure Categories

Procedure Category	ICD-9 Code	CPT Code
LRYGB	44.38	43644,43645
LAGB	44.95	43770,43843
Others	43.89, 44.68, 44.39	43999, 43842, 43846

Statistical Analysis

Bivariate statistical comparisons were made by using the χ^2 test for categorical variables and the Mann-Whitney test for continuous variables without a normal distribution. Multinomial multivariate logistic regression was used to determine the relative risks (RRs) of undergoing different procedure types on the basis of insurance coverage. Other independent variables are grouped into either hospital or patient variables. Hospital variables include hospital volume (quartiles), children's hospital status, and bariatric-center-of-excellence designation. Patient variables include age, gender, race, and distance traveled (continuous in miles). The bootstrap technique, using 1000 repetitions, was use to create 95% confidence intervals of the RRs. Bootstrapping is a resampling technique that estimates the SE of the statistics of interest (eg, RRs) by repeatedly drawing smaller "bootstrap samples" from the original data.[36]

RESULTS

Five hundred ninety adolescents between the ages of 13 and 20 years underwent bariatric surgery in California during 2005–2007. The majority (78%) of these adolescents were female, the median age was 19 years (Table 2), and 18% of the surgeries were performed on children younger than 18 years.

Receipt of Bariatric Surgery According to Race and Gender

Although white adolescents represented only 28% of those who were overweight in California, they accounted for >65% of the adolescents who had bariatric surgery between 2005 and 2007. In contrast, although 52% of the overweight adolescents were of Hispanic descent, only 21% of those who underwent bariatric surgery were Hispanic (Fig 1). Girls represented only 43% of the overweight adolescents. In contrast, they accounted

TABLE 2 Patient Characteristics

Female, *n* (%)	462 (78)
Race, *n* (%)	
White	385 (65)
Hispanic	123 (21)
Other	82 (14)
Age	
Median (25th–75th percentile), y	19 (18–20)
<18 y, *n* (%)	106 (18)
Insurance, *n* (%)	
Private	420 (71)
Public	68 (12)
Self-pay	101 (17)
Distance traveled, median (25th–75th percentile), miles	37 (15–85)
Hospital volume, *n* (%)	
High	127 (22)
Mid	362 (61)
Low	101 (17)
Centers of excellence, *n* (%)	388 (66)
Children's hospitals, *n* (%)	43 (7)

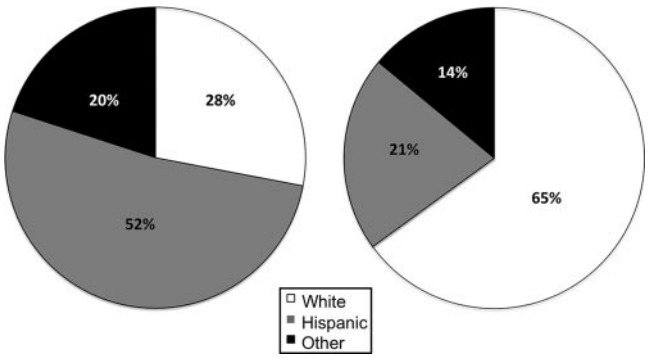

FIGURE 1
Prevalence of overweight adolescents (left) ($n = 1\ 191\ 378$) versus distribution of bariatric surgery (right) ($n = 589$) in California, 2005–2007.

for 78% of the adolescent patients who underwent surgery.

Procedure Location

Patients traveled a median distance of 37 miles (25th–75th percentile: 15–85 miles) for their surgery. The majority of procedures (61%) were performed in midvolume centers (Table 2). All of the LRYGBs were performed as inpatient operations in hospitals, and 46% of the LAGBs were performed in ASCs ($P < .01$) (Table 3). Although 71% of the LRYGBs were performed at a center of excellence defined by either the American College of Surgeons or the American Society of Metabolic and Bariatric Surgery, only 37% of the LAGBs were performed at a center of excellence ($P < .01$). The percentage of bariatric surgeries performed at a children's hospital was low (7%) and did not differ according to procedure type.

Procedure Rates Over Time

Although the incidence of adolescent bariatric surgery remained stable over the study period at 4.9 per 100 000 adolescents in California, there was a significant shift in the procedure type (Fig 2). Rates of LAGB increased fivefold from 0.3 to 1.5 per 100 000 adolescents ($P < .01$), whereas LRYGB rates decreased from 3.8 to 2.7 per 100 000 adolescents ($P < .01$). When only adolescents younger than 18 years were analyzed, this shift in procedure preference was even more pronounced. In 2007, the number of LAGBs had surpassed LRYGBs in California in those younger than 18 years (Fig 3).

Insurance Status and Type of Procedure Performed

The primary payer was private insurance in 71%, public insurance in 12%, and self-pay in 17% (Table 2) of the procedures. Adolescents who had LRYGB were more likely to have private insurance as their primary payer compared with those who had LAGB (80% vs 49%; $P < .01$) and less likely to be self-payers (8% vs 46%; $P < .01$). Using multinomial multivariate logistic regression while controlling for both hospital and patient characteristics, we found that patients with private insurance were less likely to undergo LAGB (RR: 0.21 [95% confidence interval: 0.09–0.32]) (Table 4) compared with LRYGB. On the other hand, self-payers were more likely to undergo LAGB (RR: 3.51 [95% confidence interval: 2.11–5.32]) and less likely to undergo LRYGB (RR: 0.45 [95% confidence interval: 0.33–0.58]).

Postoperative Outcomes

As a result of the increasing use of LAGB throughout the study period, the lengths of follow-up differed significantly for LAGB and LRYGB in our patient cohort. Initial hospital length of stay was significantly different between patients who had LRYBG and those who had LAGB. The mean follow-up for LAGB was 12 ± 9 months, whereas for LRYGB the adolescents were tracked, on average, for 18 ± 10 months ($P < .01$) (Table 3).

In-hospital complications occurred in 5.6% of the patients. Postoperative atelectasis (1.3%) and ileus (1.6%) were the most common in-hospital complications. Nonetheless, anastomotic leak, acute renal failure requiring dialysis, and postoperative bleeding did occur in <1% of them.

TABLE 3 Location and Outcomes of Adolescent Bariatric Surgery in California According to Location, 2005–2007

	LRYGB ($N = 409$)	LAGB ($N = 106$)	*P*
Location, %			
ASC	0	46	<.01
Centers of excellence	71	37	<.01
Children's hospital	7	11	NS
Outcome			
Length of initial stay, mean ± SD, d	2.3 ± 0.1	0.6 ± 0.7	<.01
Follow-up, mean ± SD, mo	18 ± 10	12 ± 9	NS
Mortality, %	0	0	NS
In-hospital complications, %	5.9	2.8	NS
Readmissions, %	11.5	4.7	NS
ED visits, %	9.3	7.6	NS
ASC encounters, %	7.1	1.9	NS
Reoperations, %	2.9	4.7	NS
Time to reoperation, mean ± SD, mo	6 ± 8	12 ± 7	NS

NS indicates not significant.

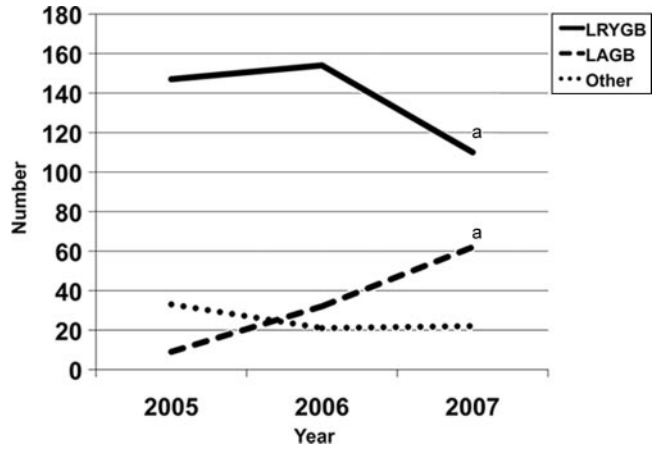

FIGURE 2
Adolescent bariatric surgery in California, 2005–2007, according to procedure type. [a] $P < .01$.

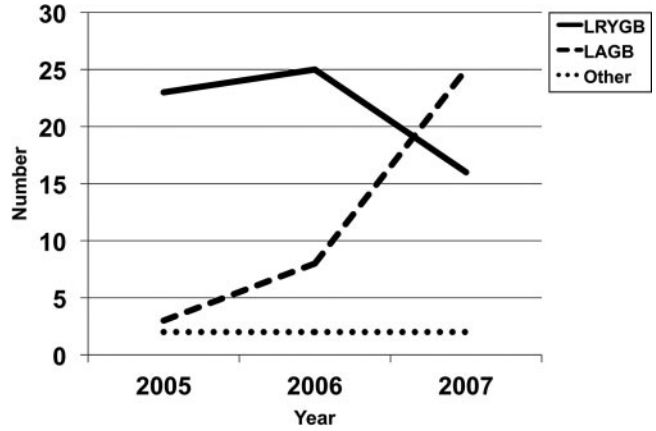

FIGURE 3
Adolescent bariatric surgery in California 2005–2007, according to procedure type in those who are younger than 18 years.

Postoperative readmission, ED visit, and additional postoperative ASC procedure rates were 10.3%, 9.0%, and 5.6%, respectively, and there was no significant difference between LRYGB and LAGB. Reoperation was necessary after LRYGB for 2.9% of the patients, whereas band revision or removal was needed after LAGB for 4.7% of the adolescents. There was no postoperative mortality observed in our study after either LAGB or LRYGB. Furthermore, center-of-excellence status, hospital type, and hospital volume did not affect postoperative outcomes in our study.

DISCUSSION

There has been a dramatic shift in the type of bariatric procedures performed on adolescents in California over a 3-year period. There was a sevenfold increase in the rate of LAGB, with a corresponding decrease in LRYGB. Although gastric banding has not yet been approved by the Food and Drug Administration for use in adolescents younger than 18 years, the increase in use of it was most pronounced in this age group. In fact, data from the end of our study period indicate that LAGB overtook LRYGB as the most frequently performed bariatric surgery procedure in patients younger than 18 years. This increase in the use of LAGB occurred during a time at which there was a significant increase in the intensity of marketing and propensity to use LAGB in morbidly obese adults.[37]

Adolescent bariatric surgery was disproportionately underused by nonwhites and boys. This conclusion is based on the assumption that the prevalence of overweight adolescents accurately estimates the prevalence of patients who are eligible for bariatric surgery. In fact, only a small percentage of patients who are overweight (BMI $\geq$ 85th percentile) are eligible for bariatric surgery. Current criteria for adolescent bariatric surgery include a BMI of $>$35 with major comorbidities or a BMI of $>$40 with minor comorbidities.[11] In addition, patients are generally required to have reached physical/skeletal maturity and undergo a trial of behavior therapy and psychosocial evaluation.[38] Despite the limitations inherent in making population-based estimates, discrepancies in the use of bariatric surgery according to race are quite pronounced and mirror those seen in the adult population.[39]

TABLE 4 Impact of Insurance on Procedure Performed: RRs From a Multinomial Multivariate Logistic Regression

	RR of Insurance on Procedure Type		
	Private Insurance	Public Insurance	Self-pay
LRYGB	1 (reference)	0.89 (0.67–1.11)	0.45 (0.33–0.58)[a]
LAGB	0.21 (0.09–0.32)[a]	0.86 (0.01–1.88)	3.51 (2.11–5.32)[a]

Covariates include hospital volume, children's hospital status, bariatric centers of excellence, age, gender, race, distance traveled, and year of operation.
[a] $P < .05$.

Several explanations have been proposed to explain the disparate use of bariatric surgery. Ethnic differences in perception of weight have been noted in nonwhites, patients with low education levels, and males.[19] Referral for bariatric surgery may also be influenced by community or primary care provider biases,[21] as well as restrictions placed by insurance companies. Surgeons are also less inclined to perform surgery on younger patients, patients who are underinsured, those with poor social support, and males.[20] Financial incentives and concerns about less successful outcomes in these groups (regardless of whether they are validated) likely influence these perceptions.

We also observed that gastric-band procedures are often performed on self-payers at ASCs. Although use of the gastric band is increasing, gastric bypass remains the gold standard of weight-loss surgery for both adults and adolescents because of better weight loss and comorbidity resolution and proven durability.[11,40] For these reasons, insurance companies may be less likely to cover gastric banding than gastric bypass, especially when used off-label for patients younger than 18 years.

The majority of adolescent bariatric surgery (93%) was performed in health care settings that are not affiliated with nationally recognized children's hospitals (National Association of Children's Hospitals and Related Institutions). Although many children's hospitals have health care professionals who are dedicated to adolescent health and psychosocial well-being, many do not have the infrastructure in place to manage the surgical care of patients with extreme obesity. A significant investment including specialized operating room tables and instruments as well as specialized personnel including dietitians and nurse coordinators are required to establish a bariatric surgery center. In this study, the majority (71%) of LRYGBs and only 37% of LAGBs took place in centers of excellence. Many have advocated that bariatric surgery should be limited to centers of excellence. Our data did not demonstrate a significant difference in postoperative outcomes according to center-of-excellence status, hospital type, or hospital volume. However, the low overall number of adolescents and relatively small volumes per hospital may be inadequate to detect any significant differences. It is interesting to note that more recent adult data have suggested that high volume and center-of-excellence status may not be as predictive of good outcomes as was originally expected.[41,42]

Our data revealed no deaths and a relatively low in-hospital complication rate (<6%). These results are similar to those reported from other outcomes studies.[17,18,43] Although surgical technique, perioperative care, and patient selection have reduced the in-hospital complication rates, the utilization of health care postoperatively is not insignificant. However, we were unable to determine for comparison the anticipated utilization of health care by patients who did not undergo surgery.

Manufacturers have touted LAGB as being less invasive, adjustable, and reversible. We observed a shorter initial length of stay but comparable complication rates. The band removal and revision rate was 4.7% despite a relatively short mean follow-up period of 1 year. In Europe, where there is greater experience with the band, several groups have reported higher reoperative rates for dysphagia, band migration, port displacement, and infection in younger patients.[44,45] More recently, an Australian group reported a 33% reoperation rate for patients aged 14 to 18 years who underwent LAGB in a prospective randomized controlled trial.[13] Many centers have abandoned gastric banding because of poor long-term results, the need for frequent adjustments, the complications associated with implantation of a foreign body, and concerns with chronic esophageal obstruction.

Similar to other studies in which an administrative database was used, our study has some limitations. Administrative data lack important clinical (BMI) and physiologic information (severity of comorbidities) not accounted for by ICD-9 coding, and observational data may not capture potential sources of bias that arise from patient-selection factors. We were not able to evaluate changes in BMI, resolution of comorbidities, or health care costs. Furthermore, the OSHPD database did not capture patient visits at unaccredited ASCs or outpatient clinics. Therefore, our results may underestimate the total number of adolescent patients who underwent bariatric surgery and the total number of postoperative health care visits. We also were unable to confirm whether patients included in the study met recommended guidelines for bariatric surgery. Nonetheless, our study is unique in its ability to link databases for different health care settings and identify individual patient ED visits, readmissions, and reoperations. In addition, using population-based data from a large and diverse state population constituting 12% of the US population, we were able to identify robust estimates on the factors that affect choice of procedure and rates of postoperative health care use.

CONCLUSIONS

Although LRYGB is still the standard of care for morbidly obese adolescents who seek surgical intervention, our study of adolescent bariatric surgery in California between 2005 and 2007 revealed a dramatic increase in the use of LAGB. Despite not being ap-

proved by the Food and Drug Administration for use in adolescents younger than 18 years, LAGB overtook LRYGB as the most frequently performed bariatric procedure in this age group. We also observed that whites and females disproportionally underwent bariatric procedures more often despite lower rates of being overweight when compared with nonwhites and males. We found relatively low rates of in-hospital complications and postoperative health care utilization. Additional studies on the efficacy, safety, and health care costs of weight-loss surgery in the adolescent population are needed to properly counsel patients and to help guide health policy.

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