ONLINE FIRST

Prevalence of Alcohol Use Disorders Before and After Bariatric Surgery

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Context Anecdotal reports suggest bariatric surgery may increase the risk of alcohol use disorder (AUD), but prospective data are lacking.

Objective To determine the prevalence of preoperative and postoperative AUD, and independent predictors of postoperative AUD.

Design, Setting, and Participants A prospective cohort study (Longitudinal Assessment of Bariatric Surgery-2) of adults who underwent bariatric surgery at 10 US hospitals. Of 2458 participants, 1945 (78.8% female; 87.0% white; median age, 47 years; median body mass index, 45.8) completed preoperative and postoperative (at 1 year and/or 2 years) assessments between 2006 and 2011.

Main Outcome Measure Past year AUD symptoms determined with the Alcohol Use Disorders Identification Test (indication of alcohol-related harm, alcohol dependence symptoms, or score ≥8).

Results The prevalence of AUD symptoms did not significantly differ from 1 year before to 1 year after bariatric surgery (7.6% vs 7.3%; $P=.98$), but was significantly higher in the second postoperative year (9.6%; $P=.01$). The following preoperative variables were independently related to an increased odds of AUD after bariatric surgery: male sex (adjusted odds ratio [AOR], 2.14 [95% CI, 1.51-3.01]; $P<.001$), younger age (age per 10 years younger with preoperative AUD: AOR, 1.31 [95% CI, 1.03-1.68], $P=.03$; age per 10 years younger without preoperative AUD: AOR, 1.95 [95% CI, 1.65-2.30], $P<.001$), smoking (AOR, 2.58 [95% CI, 1.19-5.58]; $P=.02$), regular alcohol consumption (≥2 drinks/week: AOR, 6.37 [95% CI, 4.17-9.72]; $P<.001$), AUD (eg, at age 45, AOR, 11.14 [95% CI, 7.71-16.10]; $P<.001$), recreational drug use (AOR, 2.38 [95% CI, 1.37-4.14]; $P=.01$), lower sense of belonging (12-item Interpersonal Support Evaluation List score per 1 point lower: AOR, 1.09 [95% CI, 1.04-1.15]; $P=.01$), and undergoing a Roux-en-Y gastric bypass procedure (AOR, 2.07 [95% CI, 1.40-3.08]; $P<.001$; reference category: laparoscopic adjustable gastric band procedure).

Conclusion In this cohort, the prevalence of AUD was greater in the second postoperative year than the year prior to surgery or in the first postoperative year and was associated with male sex and younger age, numerous preoperative variables (smoking, regular alcohol consumption, AUD, recreational drug use, and lower interpersonal support) and undergoing a Roux-en-Y gastric bypass procedure.

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As the prevalence of severe obesity increases in the United States,[1] it is becoming increasingly common for health care providers and their patients to consider bariatric surgery, which is the most effective and durable treatment for severe obesity.[2] Although bariatric surgery may reduce long-term mortality,[3,4] and it carries a low risk of short-term serious adverse outcomes,[5] safety concerns remain. Anecdotal reports suggest that bariatric surgery may increase the risk for alcohol use disorders (AUD; ie, alcohol abuse and dependence).[6] However, only 3 studies have examined AUD before and after bariatric surgery.

Mitchell et al[7] attempted to contact 100 patients who had received the Roux-en-Y gastric bypass (RYGB) procedure in the prior 13 to 15 years. Of 8 deaths, 1 was attributed to complications due to alcoholism. Of 78 patients who agreed to a diagnostic interview, 10 (12.8%) reported AUD prior to surgery and 6 (7.7%) reported AUD after surgery. Ertelt et al[8] mailed a survey to 250 patients 6 to 10 years after RYGB was performed. Of 70 respondents, the number who had AUD symptoms was similar prior to surgery (n=6; 8.6%) and after surgery (n=7; 10.0%). Importantly, the majority (71.4%) who had AUD symptoms postoperatively also had AUD symptoms preoperatively. Suzuki et al[9] recruited 51 of 530 targeted patients who had RYGB or laparoscopic adjustable gastric banding (LAGB) in the prior 2 or more years. Preoperative AUD was determined by retrospectively exam-

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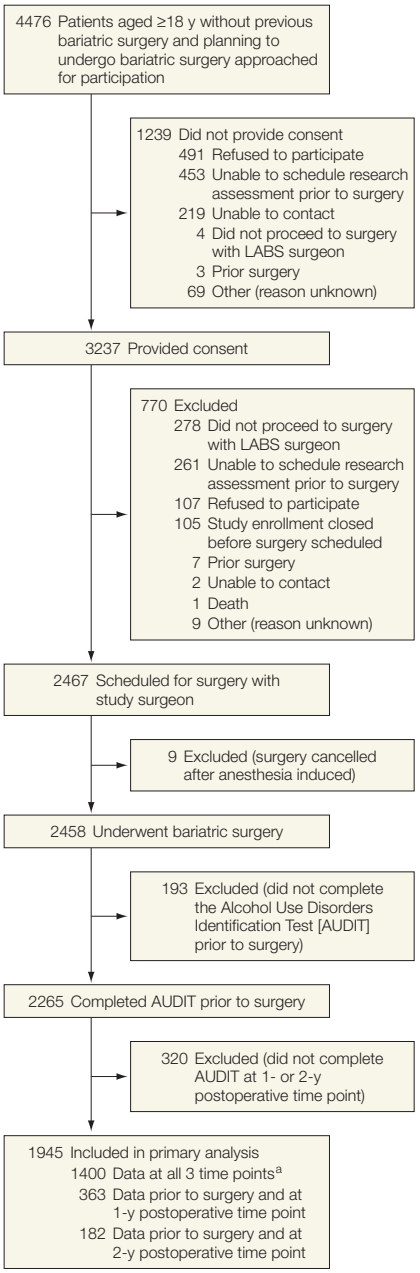
ining clinical psychiatric evaluations. Postoperative AUD was determined by diagnostic interview. No patients met the criteria for current preoperative AUD, and none who received LAGB (n=23) reported current postoperative AUD. However, 6 of the 28 patients (21.4%) who received RYGB reported current AUD; 83.3% of whom had a history of preoperative AUD with remission at time of surgery.[9] Given the limitations of these studies (low participation rate,[8,9] small sample size,[7-9] retrospective assessments of AUD,[7-9] and different time frames[7,8] and assessment methods[9] for preoperative and postoperative periods), it remains unclear whether bariatric surgery influences risk of AUD.

There is evidence that some bariatric surgical procedures (ie, RYGB and sleeve gastrectomy) alter the pharmacokinetics of alcohol. Given a standardized quantity of alcohol, patients reach a higher peak alcohol level after surgery compared with case-controls[10,11] or their preoperative levels.[12,13] In addition, some studies have shown that patients reach peak alcohol level more quickly after surgery,[11] or take more time to return to a sober state.[10,12,13] Patient surveys have revealed similar changes in alcohol sensitivity following RYGB (feeling intoxicated more rapidly, after drinking less, for longer[8,14]), as well as more difficulty controlling alcohol intake.[14] Alcohol sensitivity studies have not been performed in patients who have received LAGB, most likely because the anatomical and physiological changes from this procedure are less likely to affect alcohol absorption and metabolism.

To address limitations in the literature, this study aimed to determine whether the prevalence of AUD changed following bariatric surgery in a large multicenter observational study, comparing reported AUD in the year prior to surgery with the first and second years after surgery. In addition, this study aimed to identify independent predictors of postoperative AUD. We hypothesized that preoperative AUD and undergoing RYGB would increase the likelihood of postoperative AUD. In addition, we hypothesized that many of the factors associated with AUD in the general population[15] would be associated with increased odds of postoperative AUD.

Figure. Flow of Patients in the Longitudinal Assessment of Bariatric Surgery-2 (LABS-2) Study



Some analyses included slightly smaller samples due to missing covariate data.
[a]Presentation of descriptive statistics was limited to participants with AUDIT data at all 3 time points.

METHODS

Participants

An observational study, the Longitudinal Assessment of Bariatric Surgery-2 (LABS-2) was designed to assess the risks and benefits of bariatric surgery.[16] Patients who were at least 18 years old and seeking a first bariatric surgical procedure from participating surgeons at 10 centers throughout the United States were recruited between February 2006 and February 2009. All participating centers had institutional review board approval and all participants provided written informed consent. By study enrollment closure (April 2009), 2458 participants attended a preoperative research visit, which occurred after the surgery approval process was complete and within 30 days of their scheduled surgery date, and underwent a bariatric surgical procedure (RYGB, LAGB, sleeve gastrectomy, biliopancreatic diversion with duodenal switch, or banded gastric bypass) as part of clinical care (FIGURE).

Measures

Measures were collected independently of the surgery approval process and clinical care. Participants were informed that their responses were confidential, although the informed consent document specified that investigators could take steps to prevent serious harm (eg, if suicidal ideation was reported).

Alcohol Use and AUD. The Alcohol Use Disorders Identification Test (AUDIT)[17] is a 10-item instrument developed by the World Health Organization to assess alcohol use and alcohol-related consequences in the prior 12 months, and has well-established validity and reliability.[18] A total score (range: 0-40) is calculated using all 10 items (eTable 1 at http://www.jama.com), with a higher score reflecting greater severity of AUD. Additionally, subsets of items indicate whether respondents are positive for consumption at a hazardous level (typically consuming ≥3 drinks per occasion or ever having ≥6 drinks on 1 occasion), symptoms of alcohol dependence (not

being able to stop drinking once started, needing a drink in the morning to get going, or failing to meet normal expectations because of drinking), and alcohol-related harm (not being able to remember events, feeling guilt, injuring someone, or eliciting concern from others due to drinking behavior). For this analysis, participants were categorized as having AUD symptoms (referred to as AUD throughout) if their total AUDIT score was at least 8[17] or if they were positive for symptoms of alcohol dependence or alcohol-related harm.

Other Measures. Anthropometric measurements were made using standardized protocols.[19] Body mass index was calculated as weight in kilograms divided by height in meters squared. Sociodemographics were self-reported; race was set to missing for participants who did not self-report their race as 1 or more of the investigator-defined categories (ie, white, black, Asian, American Indian/Alaska Native, Native Hawaiian/other Pacific Islander). For this analysis, race categories other than white and black were combined as other race due to low representation (TABLE 1).

Perceived social support was measured using 3 domain scores (appraisal, belonging, and tangible) from the 12-item Interpersonal Support Evaluation List (ISEL-12), with higher scores (range: 4-16) indicating greater availability of support.[20] Physical and mental health were measured using the norm-based physical component and mental component scores from the Medical Outcomes Study 36-item Short-Form Health Survey (SF-36), with higher scores (range: 0-100) indicating better functioning.[21] Depressive symptoms were measured with the Beck Depression Inventory version 1, with a higher score (range: 0-63) indicating greater severity.[22]

Use of recreational drugs, smoking status, and binge eating disorder were assessed with the LABS-2 behavioral form,[16] which included questions to assess all 5 criteria for binge eating disorder.[23] Treatment for psychiatric or emo-

Table 1. Characteristics of Participants in the Longitudinal Assessment of Bariatric Surgery-2 Study Prior to Bariatric Surgery

	Participants (N = 1945)[a]
Sociodemographics	
Sex	
Male	413 (21.2)
Female	1532 (78.8)
Age, median (IQR) [range], y	47 (38-55) [19-78]
Race	
White	1681 (87.0)
Black	182 (9.4)
Asian	3 (0.2)
American Indian/Alaska Native	13 (0.7)
Native Hawaiian/other Pacific Islander	4 (0.2)
Multiple races	37 (1.9)
Unknown	12 (0.6)
Hispanic ethnicity	89 (4.6)
Married/living as married	1239 (64.0)
Education	
≤ High school	445 (23.0)
Some college	768 (39.7)
≥College degree	722 (37.3)
Work for pay	1322 (68.2)
Household income, $	
<25 000	340 (18.0)
25 000-49 000	483 (25.6)
50 000-74 999	434 (23.0)
75 000-99 999	307 (16.3)
≥100 000	321 (17.0)
Body mass index, median (IQR) [range][b]	45.8 (41.8-51.3) [33.7-94.3]
Interpersonal support, quality of life, and mental health	
ISEL-12 score, median (IQR) [range]	
Appraisal	16 (13-16) [4-16]
Belonging	16 (12-16) [4-16]
Tangible	15 (13-16) [4-16]
SF-36 score, median (IQR) [range]	
Physical component	36.3 (27.8-44.9) [8.7-70.3]
Mental component	51.5 (42.8-57.1) [12.6-75.9]
Beck Depression Inventory score, median (IQR) [range]	7 (3-12) [0-39]
Binge eating	308 (16.1)
Past-year treatment for psychiatric or emotional problems	1106 (57.4)
Substance use	
Current smoking	43 (2.2)
Alcohol consumption ≥2 times/wk	137 (7.0)
Alcohol use disorder[c]	152 (7.8)
Recreational drug use	83 (4.3)
Surgical procedure	
Roux-en-Y gastric bypass	1360 (69.9)
Laparoscopic adjustable gastric band	490 (25.2)
Banded gastric bypass[d]	30 (1.5)
Sleeve gastrectomy	50 (2.6)
Biliopancreatic diversion with switch	15 (0.8)

Abbreviations: ISEL-12, 12-item Interpersonal Support Evaluation List; IQR, interquartile range; SF-36, Medical Outcomes Study 36-item Short-Form Health Survey.
[a] Values are expressed as No. (%) unless otherwise indicated. The number of participants across categories may not sum to the total number of participants because of missing data.
[b] Calculated as weight in kilograms divided by height in meters squared.
[c] Alcohol Use Disorders Identification Test score of 8 or greater, alcohol dependence symptoms, or alcohol-related harm.
[d] Roux-en-Y gastric bypass with a nonadjustable band during the same operation.

tional problems (hospitalization or outpatient treatment in the past 12 months or current medication use) was assessed with the LABS-2 psychiatric and emotional test survey.[16] Several LABS-2 forms (subsequent surgery form, surgeon's questionnaire, surgical procedure–specific forms, and health care utilization form) were used to collect information on surgical revisions, reversals, and new bariatric procedures that occurred after the initial bariatric procedure and before the 2-year assessment.

Statistical Analysis

Potential selection bias was examined by comparing the preoperative characteristics of participants in the LABS-2 analysis sample (N = 1945) with those excluded (n = 513) for failure to complete the AUDIT preoperatively or during one of the postoperative time points. The Pearson χ^2 test was used for categorical variables and the Wilcoxon rank sum test was used for continuous variables. Descriptive statistics of alcohol-related measures were limited to participants with AUDIT data at all 3 time points (n = 1400). Data were assumed to be missing at random (ie, the probability of missing depends only on the observed data).[24] Differences in distributions of alcohol-related measures over time were tested using generalized linear mixed models and all available observations. Pair-wise comparisons ($P < .05$) were made between each combination of the 3 time points.

Generalized linear mixed models also were used to determine predictors of postoperative AUD, using all available observations by modeling AUD as the dependent variable over time (ie, yes or no at 1 year and yes or no at 2 years). Independent variables were selected according to the alcohol literature: sex[15,25,26]; age[15,25,26]; race[15,25,26]; ethnicity[15,25,26]; marital status[15]; education[25,26]; employment status[25,26]; household income[27]; body mass index[28]; ISEL-12 appraisal, belonging, and tangible support scores[23]; SF-36 physical and mental component scores[15]; Beck Depression Inventory score[29]; binge eating[6]; treatment for psychiatric or emotional problems[29]; smoking status[26]; regular alcohol consumption (ie, ≥2 times/week); recreational drug use[26]; surgical procedure[10,11,13]; and percentage of weight loss.[30]

The following model-fitting strategies were adopted. First, preoperative characteristics and surgical procedure were considered, with site as a random effect. Variables that were not significant in the model (ie, $P \geq .05$) were removed by using backward elimination. Because backward elimination can lead to biased models and to overfitting of data, the analysis was confirmed using forward selection. Next, to assess associations between postoperative characteristics (ie, SF-36 physical and mental component scores; Beck Depression Inventory score; binge eating; treatment for psychiatric or emotional problems; ISEL-12 appraisal, belonging, and tangible support scores; smoking status; recreational drug use; and percentage of weight loss) and postoperative AUD, a separate generalized linear mixed model was fit for each postoperative characteristic, controlling for its preoperative value (data not shown). Then, postoperative characteristics that were significantly associated with postoperative AUD and their preoperative values were added to the best preoperative multivariable generalized linear mixed model. Again, backward elimination and forward selection were used for model selection; variables that were significantly related to postoperative AUD ($P < .05$), and their preoperative values were retained. Once the independent variables were determined, all potential interactions were evaluated.

Sample sizes for generalized linear mixed models predicting postoperative AUD reflect the exclusion of participants with indeterminate preoperative AUD (n = 4), participants who had a reversal of their surgical procedure (n = 4) or a new surgical procedure (n = 4) before their 1-year assessment, and participants missing covariate data (n = 20-97, depending on the model). Participants who had a reversal (n = 4) or new procedure (n = 5) between their first and second assessment were retained. However, their 2-year data were censored. All tests were 2-sided. Adjusted odds ratios and 95% confidence intervals are reported. Statistical analyses were performed using SAS software version 9.2 (SAS Institute Inc).

RESULTS

Preoperative Characteristics

Of 2458 participants in the LABS-2 study, 2280 completed at least some self-assessment forms at the preoperative visit; 2265 completed the AUDIT. The current analysis is limited to 1945 of these 2265 participants (86%) who completed the AUDIT at the 1-year postoperative assessment (n = 1763) or 2-year postoperative assessment (n = 1582) between 2006 and 2011 (Figure). Characteristics of the LABS-2 study participants included in this analysis are shown in Table 1. Compared with those excluded from these analyses, those included were older (median: 47 years vs 42 years; $P < .001$), a greater percentage were white (87.0% vs 82.0%; $P = .01$), and a smaller percentage were smokers (2.2% vs 4.1%; $P = .02$) prior to surgery. There were no significant differences between groups with respect to other characteristics.

Alcohol Use and AUD by Time Point

TABLE 2 presents select AUDIT item responses and summary measures, as well as alcohol and drug abuse treatment in the year prior to surgery and in the first and second postoperative years (all AUDIT item responses by time point are shown in eTable 1 at http://www.jama.com). The number of alcoholic drinks consumed on a typical drinking day was significantly higher in the year prior to surgery and in the second postoperative year than in the first postoperative year. Alcohol consumption at a hazardous level was significantly more common prior to surgery than after surgery. However, there was a significant increase between the first and second postoperative years. Frequency of alcohol consumption and AUD (and all

3 of its components: dependence symptoms, alcohol-related harm, and AUDIT score ≥8) significantly increased in the second postoperative year compared with the year prior to surgery or the first postoperative year.

Relationship Between Preoperative and Postoperative AUD

More than half (66/106; 62.3% [95% CI, 53.0%-71.5%]) of those reporting AUD at the preoperative assessment continued to have or had recurrent AUD within the first 2 postoperative years. In contrast, 7.9% (95% CI, 6.4%-9.4%; 101/1283) of participants not reporting AUD at the preoperative assessment had postoperative AUD. Nonetheless, more than half (101/167; 60.5% [95% CI, 53.1%-67.9%]) of postoperative AUD was reported by those not reporting AUD at the preoperative assessment.

Predictors of Postoperative AUD

Male sex, younger age, smoking, regular alcohol consumption, AUD, recreational drug use, and lower score on the ISEL-12 for belonging at the preoperative assessment and undergoing a RYGB were independently related to an increased likelihood of AUD after surgery (TABLE 3). The adjusted odds ratio for AUD in the second compared with the first postoperative year was 1.57 (95% CI, 1.26-1.96; $P<.001$). There was an interaction between preoperative AUD and age such that the adjusted odds ratio for postoperative AUD associated with preoperative AUD increased with age (eFigure).

There were no other significant interactions between covariates. Race, ethnicity, marital status, education, employment status, household income, body mass index, SF-36 physical and mental component scores, Beck Depression Inventory score, binge eating, treatment for psychiatric or emotional problems, and ISEL-12 appraisal and tangible support scores measured preoperatively were not independently related to postoperative AUD. However, a lower postoperative SF-36 mental component score was independently related to postoperative AUD, as were postoperative smoking, recre-

Table 2. Alcohol Use, Alcohol-Related Problems, and Treatment Before Bariatric Surgery and During First and Second Postoperative Years

	No. (%) of Participants[a]			*P* Value		
	Preoperative Assessment	1-y Postoperative Assessment	2-y Postoperative Assessment	Preoperative vs 1-y Postoperative Assessment	Preoperative vs 2-y Postoperative Assessment	1-y vs 2-y Postoperative Assessment
Select AUDIT items						
Frequency of alcohol consumption						
Never	578 (41.3)	628 (44.9)	580 (41.4)	.89	<.001	<.001
≤ Monthly	523 (37.4)	455 (32.5)	414 (29.6)			
2-4 times/mo	197 (14.1)	200 (14.3)	238 (17.0)			
2-3 times/wk	65 (4.6)	74 (5.3)	97 (6.9)			
≥4 times/wk	37 (2.6)	43 (3.1)	71 (5.1)			
Alcoholic drinks on a typical drinking day						
0	568 (41.8)	619 (45.5)	571 (42.0)	<.001	.22	.01
1-2	611 (44.9)	607 (44.6)	623 (45.8)			
3-4	134 (9.9)	106 (7.8)	129 (9.5)			
5-6	35 (2.6)	18 (1.3)	25 (1.8)			
7-9	8 (0.6)	8 (0.6)	11 (0.8)			
≥10	4 (0.2)	2 (0.2)	1 (0.1)			
AUDIT summary measures						
Consumption at hazardous level[b]	266 (19.6)	180 (13.3)	224 (16.5)	<.001	<.001	.02
AUDIT score ≥8[c]	36 (2.6)	43 (3.1)	76 (5.5)	.36	<.001	<.001
Alcohol dependence symptoms[d]	39 (2.8)	44 (3.2)	77 (5.5)	.44	<.001	.01
Alcohol-related harm[d]	94 (6.8)	93 (6.7)	119 (8.6)	.65	.01	.02
Alcohol use disorder[e]	106 (7.6)	101 (7.3)	133 (9.6)	.98	.01	.01
Treatment for alcohol or drug abuse in past 12 mo						
Admitted to hospital for treatment[f]	1 (0.1)	3 (0.2)	2 (0.2)	.40	.52	.87
Outpatient treatment (ie, counseling)[g]	6 (0.5)	9 (0.7)	9 (0.7)	.29	.18	.74
In hospital or outpatient treatment[h]	6 (0.5)	10 (0.8)	9 (0.7)	.16	.25	.84

Abbreviation: AUDIT, Alcohol Use Disorders Identification Test.
[a] Limited to participants with AUDIT data at all 3 time points (n=1400). The number of participants across categories may not sum to 1400 because of missing data. Differences by time point were determined with generalized linear mixed models using all available data (N=1945).
[b] Missing data for 43 participants.
[c] Missing data for 8 participants.
[d] Missing data for 9 participants.
[e] Missing data for 11 participants. Alcohol use disorder defined as an AUDIT score of 8 or greater or indication of alcohol dependence symptoms or alcohol-related harm.
[f] Missing data for 34 participants.
[g] Missing data for 101 participants.
[h] Missing data for 115 participants.

ational drug use, and treatment for psychiatric or emotional problems (TABLE 4).

Alcohol Use and AUD by Time Point and Surgical Procedure

Given the striking relationship between RYGB (vs LAGB) and AUD (Table 3 and Table 4), we repeated the analysis evaluating alcohol consumption and AUD by time point stratifying by surgical procedure (eTable 2). Frequency of alcohol consumption significantly increased in the second postoperative year compared with the year prior to surgery or the first postoperative year among participants who underwent RYGB or LAGB.

Among participants who underwent RYGB, the number of drinks on a typical drinking day was significantly lower during the first postoperative year but not the second postoperative year compared with the year prior to surgery. In addition, the prevalence of AUD significantly increased during the second postoperative year (7.0% [95% CI, 5.4%-8.6%] the year prior to surgery and 7.9% [95% CI, 6.3%-9.8%] in the first postoperative year vs 10.7% [95% CI, 8.8%-12.7%] in the second postoperative year; $P<.001$). However, there was neither a significant difference in the number of drinks on a typical drinking day by time among participants who underwent LAGB, nor was there a significant change in the prevalence of AUD (9.3% [95% CI, 6.3%-12.3%] prior to surgery and 5.6% [95% CI, 3.2%-8.0%] for the first postoperative year vs 7.0% [95% CI, 4.4%-9.7%] for the second postoperative year; $P=.24$).

COMMENT

Despite physician[31] and patient[6] concerns that bariatric surgery increases risk of AUD, to our knowledge, this is

Table 3. Preoperative Predictors of Alcohol Use Disorder in the First or Second Postoperative Year

	No. of Participants	No. (%) of Participants With AUD by Postoperative Assessment		AOR (95% CI)[a]	*P* Value
		At 1 y	At 2 y		
Preoperative characteristics					
Sex					
Female	1514	95 (6.3)	110 (7.3)	1 [Reference]	<.001
Male	399	39 (9.8)	45 (11.3)	2.14 (1.51-3.01)	
Interaction of age × AUD					.01
Age per 10 y younger[b]					
Without AUD				1.95 (1.65-2.30)	<.001
With AUD				1.31 (1.03-1.68)	.03
Smoking					
No	1871	126 (6.7)	148 (7.9)	1 [Reference]	.02
Yes	42	8 (19.1)	7 (16.7)	2.58 (1.19-5.58)	
Regular alcohol consumption					
No	1778	89 (5.0)	108 (6.1)	1 [Reference]	<.001
Yes (≥2 drinks/wk)	135	45 (33.3)	47 (34.8)	6.37 (4.17-9.72)	
AUD					
No	1765	72 (4.1)	93 (5.3)	1 [Reference]	
Yes	148	62 (41.9)	62 (41.9)		.33
At age 20 y[c]				4.15 (2.00-8.63)	<.001
At age 45 y[c]				11.14 (7.71-16.10)	<.001
At age 60 y[c]				20.14 (10.77-37.65)	<.001
Recreational drug use					
No	1830	119 (6.5)	135 (7.4)	1 [Reference]	.01
Yes	83	15 (18.1)	20 (24.1)	2.38 (1.37-4.14)	
ISEL-12 belonging score, /1 point lower				1.09 (1.04-1.15)	.01
Surgical procedure					
Laparoscopic adjustable gastric band	485	26 (5.4)	27 (5.6)	1 [Reference]	
Roux-en-Y gastric bypass	1339	103 (7.7)	122 (9.1)	2.07 (1.40-3.08)	<.001
Banded gastric bypass	28	1 (3.6)	0	0.26 (0.02-3.04)	.28[d]
Sleeve gastrectomy	46	1 (2.2)	3 (6.5)	0.80 (0.24-2.75)	.73[d]
Biliopancreatic diversion with switch	15	3 (20.0)	3 (20.0)	2.72 (0.70-10.52)	.15[d]
Time					
First postoperative year	1913	134 (7.0)		1 [Reference]	<.001
Second postoperative year	1913		155 (8.1)	1.57 (1.26-1.96)	

Abbreviations: AOR, adjusted odds ratio; AUD, alcohol use disorder; ISEL-12, 12-item Interpersonal Support Evaluation List.
[a] Adjusted for all other variables in this table. Due to missing covariate data, analyses based on 1913 participants.
[b] The AOR differs by alcohol use disorder status.
[c] The AOR differs by age. The reference category is no alcohol use disorder at the same age. In addition, AORs are presented by age in the eFigure at http://www.jama.com.
[d] Analysis is underpowered to detect a difference between this surgical procedure and the reference category.

Table 4. Preoperative and Postoperative Predictors of Alcohol Use Disorder in the First or Second Postoperative Year

	No. of Participants	No. (%) of Participants With AUD by Postoperative Assessment		AOR (95% CI)[a]	*P* Value
		At 1 y	At 2 y		
Preoperative characteristics					
Sex					
Female	1454	94 (6.5)	110 (7.6)	1 [Reference]	<.001
Male	386	38 (9.8)	45 (11.7)	2.30 (1.63-3.26)	
Interaction of age × AUD					.03
Age per 10 y younger[b]					
Without AUD				1.80 (1.53-2.13)	<.001
With AUD				1.32 (1.03-1.69)	.03
Smoking					
No	1800	125 (6.9)	148 (8.2)	1 [Reference]	.34
Yes	40	7 (17.5)	7 (17.5)	1.51 (0.64-3.55)	
Regular alcohol consumption					
No	1709	88 (5.2)	108 (6.3)	1 [Reference]	<.001
Yes (≥2 drinks/wk)	131	44 (33.6)	47 (35.9)	7.60 (4.94-11.68)	
AUD					
No	1695	72 (4.3)	93 (5.5)	1 [Reference]	.17
Yes	145	60 (41.4)	62 (42.8)		
At age 20 y[c]				4.54 (2.15-9.56)	<.001
At age 45 y[c]				9.90 (6.82-14.38)	<.001
At age 60 y[c]				15.82 (8.47-29.57)	<.001
Recreational drug use					
No	1759	117 (6.7)	135 (7.7)	1 [Reference]	
Yes	81	15 (18.5)	20 (24.7)	1.10 (0.57-2.09)	.78
ISEL-12 belonging score, /1 point lower				1.07 (1.01-1.13)	.03
SF-36 mental component score, /10 fewer points				0.99 (0.83-1.17)	.87
Treatment for psychiatric or emotional problems					
No	788	51 (6.5)	66 (8.4)	1 [Reference]	.02
Yes	1052	81 (7.7)	89 (8.5)	0.65 (0.45-0.94)	
Surgical procedure					
Laparoscopic adjustable gastric band	470	24 (5.1)	27 (5.7)	1 [Reference]	
Roux-en-Y gastric bypass	1286	103 (8.0)	122 (9.5)	2.12 (1.43-3.15)	<.001
Banded gastric bypass	26	1 (3.9)	0	0.24 (0.02-2.55)	.24[d]
Sleeve gastrectomy	43	1 (2.3)	3 (7.0)	0.84 (0.26-2.78)	.77[d]
Biliopancreatic diversion with switch	15	3 (20.0)	3 (20.0)	1.82 (0.39-8.55)	.45[d]
Postoperative[e]					
Smoking					
No	1541	106 (6.9)	118 (8.7)	1 [Reference]	.01
Yes	133	25 (18.8)	36 (24.0)	1.83 (1.22-2.76)	
Recreational drug use					
No	1610	112 (7.0)	128 (8.9)	1 [Reference]	
Yes	63	19 (30.2)	27 (45.0)	3.09 (1.76-5.43)	<.001
SF-36 mental component score, /10 fewer points				1.28 (1.12-1.45)	<.001
Treatment for psychiatric or emotional problems					
No	1029	69 (6.7)	77 (8.6)	1 [Reference]	.01
Yes	639	62 (9.7)	77 (13.0)	1.73 (1.23-2.45)	
Time					
First postoperative year	1840	132 (7.2)		1 [Reference]	<.001
Second postoperative year			155 (8.4)	1.55 (1.24-1.95)	

Abbreviations: AOR, adjusted odds ratio; AUD, alcohol use disorder; ISEL-12, 12-item Interpersonal Support Evaluation List; SF-36, Medical Outcomes Study 36-item Short-Form Health Survey.

[a] Adjusted for all other variables in this table. Due to missing covariate data, analyses based on 1840 participants.

[b] The AOR differs by alcohol use disorder status.

[c] The AOR differs by age. The reference category is no alcohol use disorder at the same age.

[d] Analysis is underpowered to detect a difference between this surgical procedure and the reference category.

[e] This table shows the number of participants with postoperative variables at the 1-year assessment. At the 2-year assessment, there were 1456 nonsmokers and 150 smokers, 1438 not using recreational drugs and 60 using recreational drugs, and 896 not receiving treatment for psychiatric or emotional problems and 591 receiving treatment for psychiatric or emotional problems.

the first prospective investigation of AUD before and after bariatric surgery. This study found a significantly higher prevalence of AUD in the second postoperative year overall, and specifically after RYGB, compared with the years immediately before and following surgery. Although the increase in prevalence of AUD from 7.6% prior to surgery to 9.6% at the 2-year postoperative assessment may seem small, that 2% increase potentially represents more than 2000 additional people with AUD in the United States each year,[32] with accompanying personal, financial, and societal costs.[33]

Participants were categorized as having AUD if they reported at least 1 symptom of alcohol-related harm or alcohol dependence, likely identifying some participants who would not meet *Diagnostic and Statistical Manual of Mental Disorders* (Fourth Edition) criteria for AUD.[34] Thus, comparisons with prevalence rates of AUD should be made with caution. Nonetheless, in contrast to previous studies in which preoperative prevalence of AUD has been very low (0%-2%)[35-39] (whether assessed as part of the surgical evaluation[35-37] or independently for research[38,39]), the preoperative prevalence of AUD identified in this study was high (7.6%), but similar to the prevalence of AUD in the general US population (8.5%[15]; 6.5% adjusted to match the sex distribution of bariatric surgery patients[5]).

Given that current AUD is a contraindication for bariatric surgery,[40,41] it is unclear whether the prevalence of AUD prior to surgery reflects prior removal of those with current AUD from the surgery pool or underreporting. There is some evidence that prevalence of lifetime AUD is higher among candidates for bariatric surgery (eg, 31%[38]) compared with the general US population (30%[15]; 24% if adjusted to match the sex distribution of bariatric surgery patients[5]), although results are conflicting.[35-39]

The significant increase in the prevalence of AUD following RYGB, but not LAGB is consistent with observational[9] and pharmacokinetic[10,11,13] studies. The prevalence of AUD overall, and specifically among participants who underwent RYGB, did not significantly increase until the second postoperative year, when alcohol consumption in general, and consumption at a hazardous level in particular, increased compared with the first postoperative year among participants who underwent RYGB. Therefore it was likely an increase in alcohol sensitivity following RYGB combined with resumption of higher levels of alcohol consumption in the second postoperative year, which led to the increase in AUD.

Alcohol use disorder in the year prior to surgery substantially increased the odds of AUD in the first 2 postoperative years, consistent with the chronic and recurrent nature of AUD.[15] Regular alcohol consumption prior to surgery also independently increased the likelihood of postoperative AUD.

A lower sense of belonging measured by the ISEL-12 (ie, availability of people to do things with) prior to surgery was predictive of postoperative AUD, suggesting that interpersonal social support may protect against AUD. Most other predictors of AUD identified in this study (ie, male sex, younger age, smoking, recreational drug use) have been associated with AUD in the general US population.[15,26]

We did not find a significant association between preoperative mental health, depressive symptoms, binge eating, or past-year treatment for psychiatric or emotional problems, and postoperative AUD. However, worse postoperative mental health and postoperative treatment for psychiatric or emotional problems were significantly associated with AUD, consistent with cross-sectional studies reporting associations between psychiatric disorders and AUD.[10,12,13,15] The direction of these relationships is unclear.

Percentage of weight loss was not independently related to postoperative AUD. However, results require replication. Only a few studies, to our knowledge, have investigated the inverse, with various measures of alcohol consumption, alcohol-related problems, and treatment. In a sample of 440 patients who underwent LAGB, there was a significant positive relationship between preoperative alcohol consumption and the percentage of excess weight loss at 1 year ($R=0.23$; $P=.005$).[42] In addition, 2 studies (n=80 for RYGB[43] and n=413 for RYGB, LAGB, and sleeve gastrectomy[44]) found that a history of preoperative substance use disorder (including AUD and drug abuse or dependence) in remission at time of surgery predicted better postoperative weight loss, whereas 1 study (n=207 for RYGB[45]) reported no significant association. In another study, among 160 patients who reported some weight regain after RYGB, those who reported someone had expressed concern about their postoperative alcohol or drug use (<10% of participants) had an increased odds (odds ratio, 12.7 [95% CI, 1.7-93.8]; $P=.01$) of significant regain.[30] Future studies are needed to clarify if and how postoperative weight loss is related to alcohol use and AUD and vice versa.

Although safe levels of alcohol consumption have yet to be established for patients after bariatric surgery, it is concerning that 1 in 8 participants reported consuming at least 3 drinks per typical drinking day and 1 in 6 participants reported consumption at a hazardous level in the second postoperative year, given the negative effect heavy drinking may have on vitamin and mineral status,[46] hepatic function,[46] and weight loss.[30] It is also noteworthy that alcohol or drug abuse treatment was uncommon both prior to surgery and after surgery (eg, 0.5%-0.8%; 7%-10% in those with AUD).

Major strengths of this study include the prospective design, large sample from 10 hospitals throughout the United States, and use of a validated and reliable alcohol screening tool. Some study limitations with respect to interpretation of results should be noted. First, lifetime history of AUD was not assessed. Thus, we were unable to determine whether postoperative AUD was new-onset vs recurrent. Second, while research data were col-

lected independently of the surgery approval process and clinical care, some participants may have underreported their alcohol use due to concerns that their responses would affect their surgery eligibility or social desirability. However, the fact that 7.8% of study participants reported symptoms of AUD at their preoperative research visit indicates that participants who may have withheld symptoms of AUD during their clinical assessment to qualify for surgery did not withhold this same information when completing the AUDIT for research purposes.

Third, a safety protocol was triggered to assess the need for referral when participants reported having at least 5 drinks on a typical drinking day (per AUDIT item 2), which may have led to underreporting of alcohol consumption or problems at future (ie, postoperative) assessments. Fourth, because this study does not have a control group, we cannot rule out the possibility that reporting of AUD would increase independent of surgery 2 years after baseline assessment. However, the relationship between surgical procedure and postoperative AUD (ie, higher likelihood with RYGB vs LAGB) provides evidence that the most common surgical procedure was likely at least partially responsible for the increase in postoperative AUD at 2 years. Fifth, the study was underpowered to determine if the risk of postoperative AUD was related to race or ethnicity or less common surgical procedures.

In conclusion, the prevalence of AUD was greater in the second postoperative year than prior to surgery or in the first postoperative year; this finding appears to be driven by RYGB, which accounted for 70% of surgeries and doubled the likelihood of postoperative AUD compared with LAGB. Several factors associated with AUD in the general population, including history of AUD and regular alcohol consumption, also increased the likelihood of postoperative AUD in this bariatric surgery sample. Although preoperative AUD greatly increased the likelihood of postoperative AUD, more than half of participants with postoperative AUD did not report AUD in the year prior to surgery.

This study has important implications for the care of patients who undergo bariatric surgery. Regardless of alcohol history, patients should be educated about the potential effects of bariatric surgery, in particular RYGB, to increase the risk of AUD. In addition, alcohol screening and, if indicated, referral should be offered as part of routine preoperative and postoperative clinical care. Further research should examine the long-term effect of bariatric surgery on AUD, and the relationship of AUD to postoperative weight control.

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Study concept and design: King, Mitchell.
Acquisition of data: Mitchell, Courcoulas, Pories.
Analysis and interpretation of data: King, Chen, Mitchell, Kalarchian, Steffen, Engel, Courcoulas, Pories, Yanovski.
Drafting of the manuscript: King.
Critical revision of the manuscript for important intellectual content: King, Chen, Mitchell, Kalarchian, Steffen, Engel, Courcoulas, Pories, Yanovski.
Statistical analysis: King, Chen.
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Online-Only Material: The 2 eTables and the eFigure are available at http://www.jama.com.

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