Impaired Alcohol Metabolism after Gastric Bypass Surgery: A Case-Crossover Trial

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BACKGROUND: Severe obesity remains the leading public health crisis of the industrialized world, with bariatric surgery the only effective and enduring treatment. Poor psychological adjustment has been occasionally reported postoperatively. In addition, evidence suggests that patients can metabolize alcohol differently after gastric bypass.

STUDY DESIGN: Preoperatively and at 3 and 6 months postoperatively, 19 Roux-en-Y gastric bypass (RYGB) patients' breath alcohol content (BAC) was measured every 5 minutes after drinking 5 oz red wine to determine peak BAC and time until sober in a case-crossover design preoperatively and at 6 months postoperatively.

RESULTS: Patients reported symptoms experienced when intoxicated and answered a questionnaire of drinking habits. The peak BAC in patients after RYGB was considerably higher at 3 months (0.059%) and 6 months (0.088%) postoperatively than matched preoperative levels (0.024%). Patients also took considerably more time to return to sober at 3 months (61 minutes) and 6 months (88 minutes) than preoperatively (49 minutes). Postoperative intoxication was associated with lower levels of diaphoresis, flushing, and hyperactivity and higher levels of dizziness, warmth, and double vision. Postoperative patients reported drinking considerably less alcohol, fewer preferred beer, and more preferred wine than before surgery.

CONCLUSIONS: This is the first study to match preoperative and postoperative alcohol metabolism in gastric bypass patients. Post-RYGB patients have much higher peak BAC after ingesting alcohol and require more time to become sober. Patients who drink alcohol after gastric bypass surgery should exercise caution. (J Am Coll Surg 2011;212:209–214. © 2011 by the American College of Surgeons)

Obesity is the leading public health crisis in the developed world.[1] Despite public health initiatives, obesity rates in the United States continue to increase, growing from 15% in 1980 to 33.3% of men and 35.3% of women in 2006.[2] Bariatric surgery remains the only proven effective and enduring treatment for severe obesity.[3,4] RYGB is a highly effective surgery that uses both restriction and malabsorption to achieve weight loss. RYGB patients have a 25% to 30% reduction in total weight as long as 10 years postoperation and also have a 37% decline in long-term mortality.[5,6] All disease-related mortality declines after surgery, including a 50% decreased risk of death from cardiovascular disease, a 90% decreased risk of death from diabetes, and a 62% decreased risk of death from cancer.[6]

Despite its benefits, RYGB is not without potential postoperative complications, including bleeding, anastomotic leaks, strictures, ulcers, gallstones, and micronutrient and vitamin deficiencies.[7] In addition, death from non−disease-related causes increases after surgery. The risk of mortality from suicide increases 71% and death from accidents goes up 34%.[6]

There is concern that bariatric patients have difficulty with the psychological adjustments to weight loss.[8,9] In particular, bariatric patients can undergo addiction transfer, potentially trading a food addiction to alcohol or a substance abuse problem. New onsets of major depression, alcoholism, and drug abuse after bariatric surgery have been documented in studies.[8,10-13] In addition, there is evidence that the highest rate of postoperative alcoholism is seen in patients who displayed binge-eating behavior before surgery.[14] Alcohol abuse in bariatric patients has been directly linked to mortality from automobile accidents, al-

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Abbreviations and Acronyms
BAC = breath alcohol content
BMI = body mass index
RYGB = Roux-en-Y gastric bypass

cohol poisoning, and Wernicke's encephalopathy from thiamine (vitamin B-1) deficiency.[8,9,15]

Beyond an increased mortality risk, postoperative alcohol use in bariatric patients can impact health. Alcohol consumption is associated with greater caloric intake even when adjusted for the calories in the alcoholic beverage.[16] It is possible that drinking alcohol post-RYGB can decrease weight loss, lead to weight regain, or cause nutritional deficiencies because a serving of beer contains 153 kcal, wine contains 125 kcal, and liquor has 97 kcal, and all contain little to no protein, vitamins, or micronutrients.[17] In particular, alcohol consumption can result in thiamine deficiency due to inadequate thiamine intake, decreased gastrointestinal thiamine absorption, and impaired cellular use of thiamine.[18]

There is some evidence that alcohol metabolism is altered in post−gastric bypass patients. A small study of female patients post-RYGB found that the peak venous blood alcohol levels in gastric bypass patients were considerably higher than controls matched for age and body mass index (BMI; calculated as kg/m^2).[19] We have previously shown that the peak breath alcohol content (BAC) in male and female gastric bypass patients is considerably higher than matched controls and that patients post-RYGB take longer than controls to return to sober 0% BAC levels.[20]

To date, no study has been done using a patient's preoperative alcohol metabolism as a matched control for postoperative alcohol metabolism. Using patients as their own controls will remove confounding individual variation. We hypothesize that this study will concur with previous results and therefore definitively show that gastric bypass patients' differences in alcohol metabolism are caused by RYGB surgery.

METHODS

Nineteen morbidly obese patients undergoing RYGB at a single academic institution from 2006 to 2007 were prospectively enrolled at the initial consult clinic visit. All patients qualified for surgery based on the 1991 NIH consensus criteria.[21] All RYGB procedures were performed laparoscopically by a single surgeon, with a standard 15 to 30 mL gastric pouch and 100-cm Roux limb. Weight and BMI were measured at preoperatively and 2 weeks, 6 weeks, 3 months, and 6 months post-operation per standard practice. Before bariatric surgery, all study participants underwent clearance by a dedicated bariatric psychologist. None of the patients in this study had a history of substance abuse as per our standard psychological evaluation. All substance abuse questions were modified from The National Epidemiological Survey on Alcohol and Related Conditions. This study was approved by the Stanford University Institutional Review Board.

Alcohol metabolism testing was performed preoperatively and at the 3- and 6-month postoperative follow-up visits. Patients were required to have nothing by mouth for 2 hours before testing to ensure that alcohol absorption was not confounded by gastric contents. Patients were given 5 oz red wine (Bandit Cabernet Sauvignon, 13.0% alcohol/volume) to drink in $<$ 1 minute. Time point 0 minutes was defined as when the patient finished the red wine. Blood alcohol content was estimated by BAC as measured by an AlcoHAWK Pro: Professional Edition Breathalyzer (Q3 Innovations), which has been shown to predict the arterial blood concentration by $\pm$1%.[22,23] Breath testing started 15 minutes after the last sip of wine, per breathalyzer use guidelines, and was measured every 5 minutes thereafter until the BAC reached 0%. Data used for comparison was the peak %BAC value at 15 minutes and the number of minutes required for the BAC to reach 0%. In additional to the alcohol metabolism testing, patients were given a questionnaire about their drinking habits, alcohol preferences, and CAGE (cut, annoyed, guilty, eye-opener) questionnaire, the validity of which has been established previously.[24] The CAGE questionnaire includes: Have you ever felt you should cut down on your drinking? Have people annoyed you by criticizing your drinking? Have you ever felt bad or guilty about your drinking? Have you ever had a drink first thing in the morning to steady your nerves or get rid of a hangover (eye-opener)? All post-alcohol symptom data were corrected prospectively and questions about symptoms had a potential dichotomous response of yes or no.

Statistical analysis was done by using a patient's preoperative values as a matched control. Comparisons in BAC, drinking habits, and postoperative weight loss were done with a 2-tailed Student's *t*-test and analysis of symptom changes and alcohol preference was performed with a Fisher's exact test. In addition, to control for changes in weight over time, a linear regression analysis for BAC levels was performed with BAC as the dependent variable and weight and sex as independent variables. The submitted linear regression analysis for breath alcohol

Table 1. Study Population Demographics

Age, y, mean ± SE	44.7 ± 2.4
Female, %	84.2
Caucasian, %	47.3
Preoperative weight, lb, mean ± SE	304 ± 16
Preoperative BMI,* mean ± SE	49.1 ± 2.1
3-mo postoperative BMI, mean ± SE	40.4 ± 1.8
6-mo postoperative BMI, mean ± SE	36.6 ± 1.8

*BMI, body mass index; calculated as kg/m^2.

level as dependent variable includes the absolute weight change over time. All analyses were performed using STATA Software (version 10.0) with $p < 0.05$ for significance.

RESULTS

The demographic distribution of this study was 84.2% female, 47.3% Caucasian, and a mean of 44.7 years old (Table 1). Mean BMI was 49.1 preoperation, 40.4 at 3 months postoperation, and 36.6 at 6 months postoperation.

The peak %BAC of patients after drinking 5 oz red wine was significantly different between preoperation and postoperation. BAC was 0.024% at preoperation and 0.059% ($p = 0.0003$) at 3 months and 0.088% ($p = 0.0008$) at 6 months postoperation (Table 2). The time to sober was 49 minutes at preoperation versus 61 minutes (NS) at 3 months and significantly different at 6 months postoperation at 88 minutes ($p = 0.011$) (Fig. 1, Table 3). A regression analysis was used to assess the contribution of changes in BMI and weight loss to the preoperation versus postoperation differences in BAC. Patient's sex, age, and weight loss did not contribute substantially to the differences in BAC at 3 months or 6 months (Fig. 1, Table 3).

Patient's self-reported total and composite symptoms of intoxication differed significantly between preoperation and postoperation ($p < 0.05$) (Table 2). However, the percent of patients reporting specific and individual symptoms did not significantly change after surgery ($p > 0.05$) (Table 2). During the course of this study, no patient ever answered positively to any of the 4 CAGE questions used for alcoholism screening preoperatively or 3 and 6 months postoperatively. Preoperatively, 74% of patients reported that they drank alcohol compared with 44% ($p = 0.006$) and 44% ($p = 0.010$) at 3 and 6 months postoperatively, respectively. No patient who was not a drinker preoperatively reported new onset of any alcohol use postoperatively.

Additional analysis of the drinking habits of patients who reported any alcohol use revealed that, of the patients who reported that they drank alcohol at each time point, the frequency of drinking decreased (Table 4). Patients who drank preoperation drank on average 1.9 days a week, which was significantly more than 0.9 days a week among the drinkers at 6 months postoperation ($p = 0.045$). Additionally, among the drinkers, the number of drinks consumed in one sitting declined from 2.4 preoperation to 1.5 at 6 months postoperation ($p = 0.059$). The total number of drinks consumed in a week among drinkers fell from 4.36 at preoperation to 1.75 at 6 months postoperation ($p = 0.021$) (Table 4).

Before surgery, patients' type of alcohol preference was relatively evenly distributed among beer (38%), wine (38%), and hard liquor (24%). After surgery, there was a trend toward increased wine preference at 3 months (50%, $p = 0.007$) and 6 months (58%) and decreased beer preference at 3 months (25%, $p = 0.005$) and 6 months (17%) (Table 4).

DISCUSSION

This is the first study to demonstrate gastric bypass patients' alcohol metabolism changes in a case-crossover fashion with patients acting as their own controls. Matching patients' preoperative data to postoperative data showed significant differences in alcohol metabolism after gastric bypass. After gastric bypass, consuming 5 oz red wine led to a peak breath alcohol level of 0.088% and to detectable breath alcohol levels for 88 minutes. This study concurs with 2 previous studies of alcohol metabolism after gastric bypass surgery and gives the strongest evidence to date of matched changes in alcohol metabolism.[19,20] Our previous study demonstrated virtually the same results with control subjects. This study also amplifies the conclusion with patients acting as their own controls.

A limitation of this study is that the breath alcohol measuring device has not been specifically validated in the morbidly obese patient. However, the semiconductor sensor accuracy is ±0.01% BAC at 0.10% BAC and is Department of Transportation/National Highway Traffic Safety Administration− approved as an alcohol screening device. The AlcoHAWK Pro is also 510(k)-certified by the US Food and Drug Administration. In addition, 67% of the United States is overweight/obese and the device-testing population is likely representative of the US population. Another limitation is the direct correlation between breath and blood alcohol levels. Per AlcoHawk standards and Department of Transportation/FDA standards, there is very good correlation between breath and blood alcohol testing.[22,23] Breath alcohol testing has additional validity as a legal standard for indication of intoxication. Another potential concern is

Table 2. Preoperative versus Postoperative Alcohol Metabolism

	Preoperative	3 Months	6 Months
Breath alcohol			
Peak breath alcohol content, %, mean ± SE	0.024 ± 0.004	0.059 ± 0.008*	0.088 ± 0.010*
Time to sober, min, mean ± SE	49 ± 5	61 ± 7	88 ± 9†
Symptoms, %			
Patients reporting symptoms	82	94‡	100‡
Flushing	63	41	44
Euphoria	58	88	50
Somnolence	47	53‡	44
Dizziness	42	59	63
Diaphoresis	37	18	19
Headache	37	12	13
Numbness	26	12	25
Disorientation	11	24	13
Nausea	11	0	13
Warmth	5	47	69
Double vision	0	12	25

*p Value < 0.001 compared with matched preoperative values by paired 2-sample *t*-test.
†p Value < 0.01 compared with matched preoperative values by paired 2-sample *t*-test.
‡p Value < 0.05 compared with preoperative by Fisher's exact test.
All other p values are not significant.

whether ketone production attributed to weight loss might influence breath alcohol levels. Generally, any ketone production should decline over time. In addition, one study demonstrated correlation of breath acetone levels with impaired liver pathology in preoperative bariatric surgery patients.[25] However, all patients with abnormal liver biopsy results before bariatric surgery had subsequent improvement in a long-term, longitudinal study.[26]

CONCLUSIONS

These findings have important implications for all gastric bypass patients who consume alcohol postoperatively. After drinking a single glass of wine, gastric bypass patients have breath alcohol levels greater than the legal driving limit of 0.08. However, because these patients are experiencing different symptoms of intoxication, a gastric bypass patient might not recognize that they have had too much to drink because their bodies respond differently to alcohol after surgery. Patients feel different effects of alcohol intoxication postoperatively and this can lead to overindulgence to achieve the same symptoms of intoxication that they experienced before surgery. It has been shown that gastric bypass patients struggle with the psychological adjustments of weight loss.

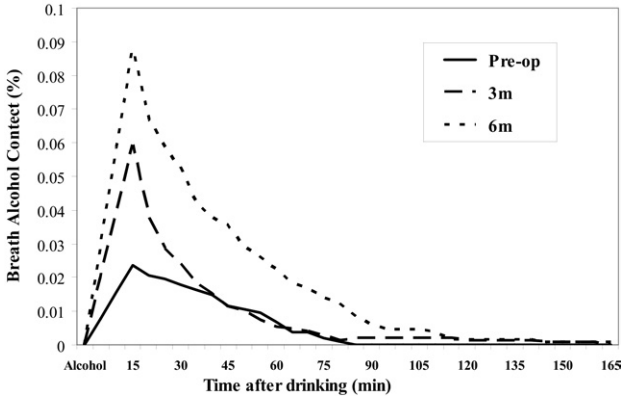

Figure 1. Breath alcohol content after gastric bypass, weight-corrected.

Table 3. Linear Regression Analysis of Alcohol Metabolism

Parameter	OR ± SE	95% CI	p Value
Peak BAC			
Female	1.006 ± .056	.877−1.154	0.924
Age	1.001 ± .002	.996−1.006	0.735
Preoperative weight	.999 ± .001	.996−1.002	0.526
3-mo weight	1.001 ± .002	.996−1.006	0.574
6-mo weight	.999 ± .001	.996−1.003	0.711
BAC time to sober			
Female	.001 ± .035	.000−.000	0.797
Age	2.237 ± 1.908	.278−18.027	0.382
Preoperative weight	.660 ± .371	.167−2.616	0.488
3-mo weight	2.847 ± 2.347	.379−21.395	0.251
6-mo weight	.451 ± .278	.010−2.041	0.244

Regressions using body mass index instead of weight produced similar, non-significant results.
BAC, breath alcohol content; OR, odds ratio.

Table 4. Preoperative versus Postoperative Drinking Habits

	Preoperative	3 Months	6 Months
Drinkers, %	74	44*	44*
CAGE score	0	0	0
Days per week that patient drinks	1.9	1.5	0.9*
Drinks per sitting	2.4	1.6*	1.5*
Total drinks per week	4.36	2.58	1.31*
Drink preference, %			
Beer	38	25	17
Wine	38	50	58
Liquor	24	25	25

*p Value <0.05 compared with matched preoperative values by paired 2-sample *t*-test. All other p values were nonsignificant.
Analysis includes only patients who reported drinking at each time point.

In addition, bariatric patients must also be careful with alcohol consumption because it can lead to weight regain after surgery. It has been shown in other studies that alcohol consumption increases caloric intake and increases lipid consumption and that calories consumed in liquids do not induce the same feelings of satiety as calories consumed from solid foods.[16] Alcohol is known to relax the lower esophageal sphincter and increase gastric emptying, which allows a person to eat larger than normal volumes of food.[27] Alcohol intoxication lowers inhibitions and can lead to episodes of binge eating in persons with a history of eating disorders. For all of these reasons, alcohol consumption can potentially lead to weight gain and must be approached with caution by bariatric patients. Our standard recommendation to post−gastric bypass patients is not to ever drink and drive and to limit consumption of alcohol to one standard unit (ie, one 12-oz beer, 5-oz wine, or 2-oz liquor) every 2 hours. Finally, our study suggests that alcohol metabolism after gastric bypass surgery is altered.

Author Contributions

Study conception and design: Woodard, Morton
Acquisition of data: Woodard, Downey
Analysis and interpretation of data: Woodard, Downey, Boussard, Morton
Drafting of manuscript: Woodard, Downey, Boussard, Morton
Critical revision: Woodard, Morton

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