Gastric Emptying of Beer in Mexican-Americans Compared With Non-Hispanic Whites

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Gastric emptying studies were performed on 11 nondiabetic Mexican-Americans and 11 nondiabetic non-Hispanic whites following ingestion of 450 mL beer. Plasma glucose, serum insulin, and serum alcohol levels were measured in the fasting state and at 7, 15, 30, 45, and 60 minutes following ingestion of the beer. The area under the gastric emptying curve was significantly larger for non-Hispanic whites compared with Mexican-Americans ($P = .0492$), indicating that Mexican-Americans had faster stomach emptying. Partial correlation coefficients (adjusted for ethnicity, gender, age, and body mass index [BMI]) showed the gastric half-emptying time was inversely related to the incremental levels of glucose ($r = -.709$, $P = .0010$) and alcohol ($r = -.650$, $P = .0035$). The faster the rate of gastric emptying of beer, the higher the glucose and alcohol levels. There were no significant correlations between insulin and the rate of gastric emptying. The caloric emptying rate for the beer was much more rapid than previously reported for other liquid meals.

OVER SIX BILLION gallons of beer are produced each year in the United States,[1] and an average of approximately 34 gallons of beer are consumed per adult.[1] Mexican-Americans, a population at high risk for diabetes mellitus and obesity,[2] favor beer as their alcoholic beverage of choice.[3] Although beer contributes approximately 7% of the total calories consumed by the average American,[1,4] little research has been performed to study the association of gastric emptying of beer with glucose homeostasis or postconsumption alcohol levels.

The rate of gastric emptying of alcoholic (non-beer) beverages has been shown to be an important factor in the rate of alcohol absorption.[5] The present investigation was undertaken to study the difference in gastric emptying of beer in Mexican-Americans and non-Hispanic whites and the effect the rate of gastric emptying of beer has on plasma glucose, serum insulin, and serum alcohol levels.

SUBJECTS AND METHODS

Subjects

The study was approved by the Institutional Review Board at the University of Texas Health Science Center at San Antonio. All subjects provided written informed consent after the nature of the procedure had been explained. Local newspaper advertisements and fliers posted around the University of Texas Health Science Center were used to solicit volunteers for the study, all of whom were accepted in consecutive order. Patients with known diabetes or who were diagnosed as diabetic or as having impaired glucose tolerance (using a 75-g glucose challenge) during the time of the study were excluded. Patients with known gastrointestinal disorders or surgery were also excluded from the study.

Potential subjects were questioned as to their average alcohol intake. All subjects enrolled in the study were regular moderate users of alcohol; that is, they drank typically the equivalent of at least one mixed drink per week or two beers per week. Subjects stating that they consumed more than four beers per day or two mixed drinks per day were excluded from the study.

Gastric emptying studies were performed on 22 subjects: 14 men and 8 women. All women studied were premenopausal, and none were taking oral contraceptives. Eleven subjects were Mexican-American and 11 non-Hispanic white. The mean age for the non-Hispanic whites was 33.3 ± 2.4 years, with a range of 22 to 45. The mean age for the Mexican-Americans was 34.3 ± 2.3 years, with a range of 23 to 48. The mean body mass index (BMI) for Mexican-American men was 30.2 ± 2.8 kg/m^2 and for women 28.1 ± 2.2. The mean BMI for non-Hispanic white men was 27.2 ± 2.4 kg/m^2 and for women 24.9 ± 2.5.

All studies were performed between 7:30 AM and noon after an overnight (12- to 15-hour) fast. No medication, with the exception of some vitamins and topical steroid creams, was being taken by any of the patients. All patients were nonsmokers.

Gastric Emptying Studies

Four hundred fifty milliliters (180 kcal: 66 kcal carbohydrate, 5 kcal protein, and 109 kcal ethanol) of Miller Genuine Draft beer (Milwaukee, WI) was poured into a plastic cup, and the foam was allowed to settle. Approximately 200 μCi technetium-99m sulfur colloid (^{99m}Tc-SC; Bedford, MA) was then added to the beer. ^{99m}Tc-SC is used commonly in nuclear imaging studies when investigating gastric physiology. It equilibrates rapidly with a liquid meal and is representative of emptying for that liquid.[6] This method of radiolabeling a liquid for the purpose of gastric emptying studies has been reported previously.[7] The patient was handed the beer and instructed to drink it in its entirety within a 5-minute period. Immediately after the patient had finished drinking the beer, consecutive 1-minute gamma-camera images were obtained in the anterior and posterior projections while the patient was standing. At 15-minute intervals, repeat consecutive 1-minute images were obtained. This study was continued for 60 minutes. Between standing-image acquisitions, the patient was allowed to sit in a chair at a 90° angle. Before leaving the testing area, each subject was given a sobriety test consisting of balancing and fine motor coordination activities.

Images were acquired with a gamma camera using a low-energy, all-purpose collimator with a 20% energy window setting centered at 140 keV. The camera was connected to a Medical Data Systems Computer (Ann Arbor, MI). Regions of interest were drawn around the stomach for all images acquired. Geometric means of the anterior and posterior images were calculated.[8] The total geometric mean counts at each 15-minute interval were converted to a percentage of the maximal geometric mean counts recorded during the study.

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Submitted January 6, 1996; accepted April 3, 1996.

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0026-0495/96/4509-0020$03.00/0

Blood Analyses

Two fasting blood samples were drawn for measurement of plasma glucose, serum alcohol, and serum insulin levels. Additional blood was drawn 7, 15, 30, 45, and 60 minutes following ingestion of the beer. All blood was collected in glass tubes (Becton Dickinson Vacutainer Systems, Rutherford, NJ). Blood for glucose analysis was collected in vacutainer tubes containing potassium oxalate and sodium fluoride. Glucose analysis, using the hexokinase method, was performed on a Paramax Chemistry Analyzer (Baxter Healthcare, Irvine, CA).

Blood for insulin and alcohol determinations was collected in separate vacutainer red-top tubes containing no preservative. Blood for the insulin assay was centrifuged, and the serum was poured off into plastic tubes and then immediately frozen until the time of assay. The assay for insulin was performed by Dr Ralph DeFronzo's laboratory at The University of Texas Health Science Center using the Diagnostic Products (Los Angeles, CA) radioimmunoassay procedure. Intraassay variation for the insulin assay was 2% and interassay variation 4%. The sensitivity of the insulin assay is 7 pmol/L.

The serum alcohol analysis was performed on a Paramax Chemistry Analyzer based on an alcohol dehydrogenase methodology. Intraassay variation for the alcohol assay was 3% and interassay variation 4%.

Statistical Analysis

We analyzed the effects of ethnicity and gender on the gastric half-emptying time, area under the gastric emptying curve, and glucose, insulin, and alcohol levels using analysis of covariance with age and BMI as covariates.[9] We calculated the area under the curve using the trapezoid rule. The analysis of the area under the curve is an important parameter because it incorporates information from the entire testing period and not from just a single time point. Mean glucose, insulin, and alcohol levels over the 1-hour period were computed from the area under the glucose, insulin, and alcohol curves, respectively. Results are expressed as the mean ± SEM. Partial correlation coefficients (adjusted for ethnicity, gender, age, and BMI) among gastric half-emptying time, glucose level, insulin level, and alcohol level were calculated. Partial correlation coefficients[9] allow us to better examine the association of gastric half-emptying time with glucose, insulin, and alcohol levels by eliminating any common association with ethnicity, gender, age, or BMI. Caloric emptying rate is calculated from the gastric half-emptying time.

RESULTS

Ethnicity

The area under the gastric emptying curve, adjusted for gender, age, and BMI, was smaller ($P = .0492$) for the Mexican-Americans, indicating that they had significantly faster gastric emptying of beer than the non-Hispanic whites (Fig 1). Following ingestion of the beer, Mexican-Americans had significantly less radiolabeled beer remaining in the stomach at 45 and 60 minutes (Fig 1) compared with non-Hispanic whites ($P < .05$).

Figure 2 shows mean incremental plasma glucose levels in the Mexican-Americans and non-Hispanic whites following ingestion of 450 mL beer. Baseline (fasting) glucose values for Mexican-Americans (5.23 ± 0.12 mmol/L) and non-Hispanic whites (5.19 ± 0.13 mmol/L) were similar ($P = .8276$). The mean incremental glucose level at 60 minutes was significantly higher in Mexican-Americans

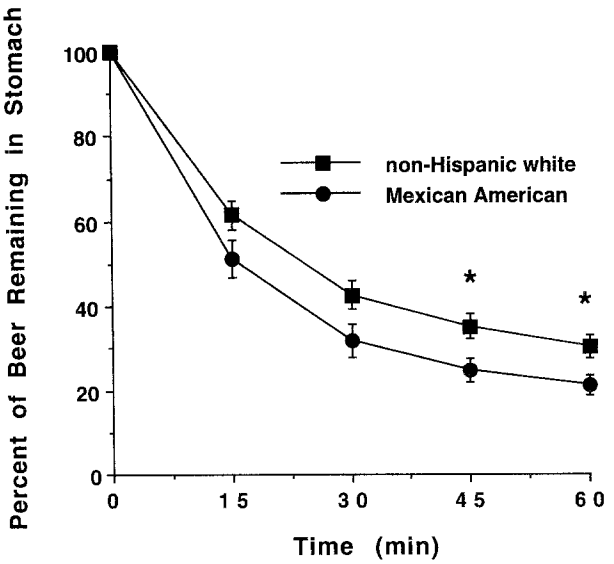

Fig 1. Mean percent of radioactively labeled beer remaining in the stomach following ingestion of 450 mL beer in 11 Mexican-American and 11 non-Hispanic white subjects. Bars indicate ± SEM (*$P < .05$).

(1.01 ± 0.19 mmol/L) compared with non-Hispanic whites (0.31 ± 0.18 mmol/L, $P < .05$).

Figure 3 shows mean incremental serum insulin levels in the Mexican-Americans and non-Hispanic whites. Baseline (fasting) insulin values were similar in Mexican-Americans (63.1 ± 9.5 pmol/L) and non-Hispanic whites (81.5 ± 9.7 pmol/L, $P = .1966$). The mean incremental insulin at 60 minutes was significantly higher in Mexican-Americans (130.7 ± 26.1 pmol/L) compared with non-Hispanic whites (48.3 ± 20.3 pmol/L, $P < .05$).

Mean alcohol levels over the 60-minute period were similar in Mexican-Americans (5.43 ± 0.47 mmol/L) and non-Hispanic whites (4.88 ± 0.48 mmol/L, $P = .4343$). There were no detectable amounts of ethanol in the fasting

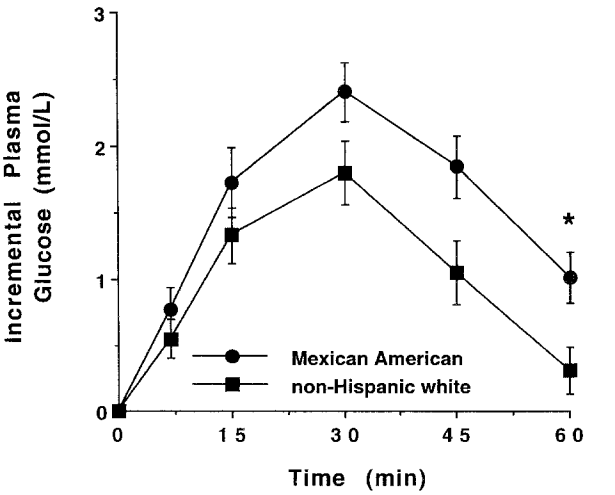

Fig 2. Mean incremental plasma glucose in 11 Mexican-American and 11 non-Hispanic white subjects following ingestion of 450 mL beer (*$P < .05$).

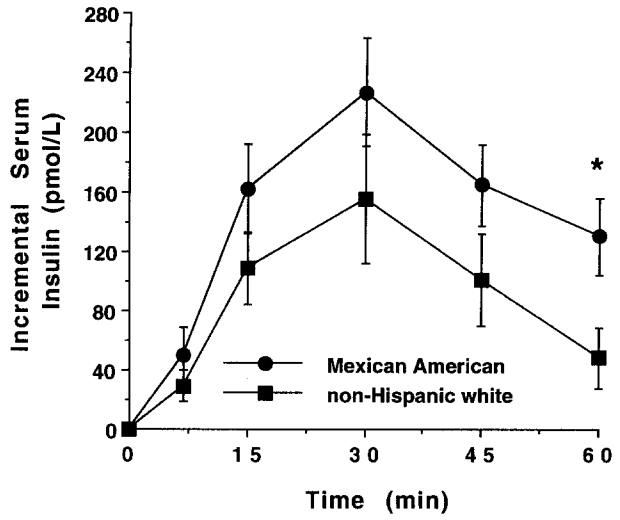

Fig 3. Mean incremental serum insulin in 11 Mexican-American and 11 non-Hispanic white subjects following ingestion of 450 mL beer (*P < .05).

blood samples. Figure 4 shows mean serum alcohol levels in the Mexican-Americans and non-Hispanic whites following ingestion of beer.

Association of Gastric Emptying Rate and Glucose, Insulin, and Alcohol Levels

Partial correlation coefficients (adjusted for ethnicity, gender, age, and BMI) between gastric half-emptying time and the mean alcohol, incremental glucose, and incremental insulin levels for all subjects are shown in Table 1. The gastric half-emptying time was inversely related to the mean incremental glucose and alcohol levels. The faster the rate of gastric emptying of beer, the higher the glucose and alcohol levels.

Partial correlation coefficients were also computed between the gastric half-emptying time and the blood alcohol and incremental glucose levels at each time blood was drawn from the subjects. At 15 (r = −.523, P = .0260), 30 (r = .685, P = .0017), and 45 (r = −.691, P = .0015) minutes, there were significant correlations between the gastric half-emptying time and the incremental glucose level. At 15 (r = −.603, P = .0081) and 30 (r = −.641, P = .0041) minutes, there were significant correlation between the gastric half-emptying time and the serum alcohol level. These correlation coefficients indicate an association between the rate of gastric emptying and the resultant glucose and alcohol levels.

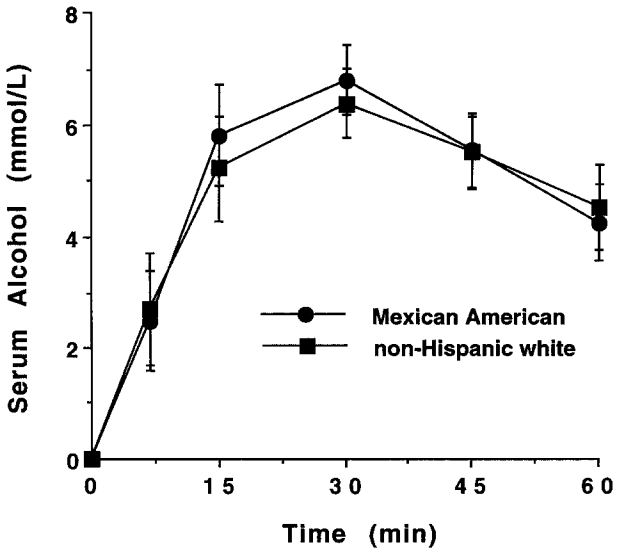

Fig 4. Mean serum alcohol in 11 Mexican-American and 11 non-Hispanic white subjects following ingestion of 450 mL beer.

Table 1. Partial Correlation Coefficients (adjusted for ethnicity, gender, age, and BMI) Between Gastric Half-Emptying Time and Mean Alcohol, Incremental Glucose, and Incremental Insulin Levels

Variable	Partial Correlation Coefficient	Significance (P)
Mean alcohol	−.650	.0035
Mean incremental glucose	−.709	.0010
Mean incremental insulin	.044	>.05*

*Not significant.

DISCUSSION

Beer emptied from the stomach of both Mexican-Americans and non-Hispanic whites very rapidly when compared with the gastric emptying rate of other liquid meals. The mean caloric emptying rate (based on the gastric half-emptying time) for the beer (carbohydrate 16 g, 66 kcal + protein 1 g, 5 kcal + ethanol 16 g, 109 kcal, for a total of 180 kcal) for all subjects was 3.9 ± 0.4 kcal/min. This high emptying rate for liquid calories has not been previously reported.

Using the same statistical analysis, we compared the gastric emptying results from studies using a dilute 50-g glucose solution versus the results of the present study using beer. The comparison showed that beer empties much faster. For Mexican-Americans, beer emptied at a rate of 4.8 ± 0.8 kcal/min, whereas in a group of 32 nondiabetic Mexican-Americans[7] a 50-g glucose solution emptied at a rate of 1.8 ± 0.1 kcal/min (P = .0001, t test). For non-Hispanic whites, beer emptied at a rate of 3.2 ± 0.4 kcal/min, whereas in a group of 31 nondiabetic non-Hispanic whites[7] a 50-g glucose solution emptied at a rate of 1.5 ± 0.1 kcal/min (P = .0001, t test). Combining three other studies of gastric half-emptying time of a 50-g glucose solution in which ethnicity was not considered (mean half-emptying times of 66,[10] 64.6,[11] and 62.7[12] minutes) yields a mean emptying rate of 1.6 ± 0.1 kcal/min. The present study had a mean emptying rate of beer, without regard to ethnicity, of 3.9 ± 0.4 kcal/min (P = .0001, t test).

Although we studied the gastric emptying of beer alone, individuals frequently ingest solid food along with beer. When gastric emptying is slowed by concomitant food intake, the rate of alcohol absorption is slowed.[13,14] The rate of gastric emptying of beer would undoubtedly be slower if solid food were ingested concomitantly. Studies involving the rate of gastric emptying of beer with solid foods should be pursued.

Several studies have described various rates of alcohol metabolism among different ethnic groups.[15-18] North American Indians, for example, have a higher alcohol metabolism rate compared to whites.[16-18] Mexican-Americans in our study exhibited a faster rate of gastric emptying than non-Hispanic whites, and yet their alcohol levels were statistically similar. Perhaps there was no difference in serum alcohol levels between the two groups because of a faster alcohol metabolic rate in the Mexican-Americans. A faster metabolic rate for alcohol in Mexican-Americans could decrease the effect of alcohol itself on gastric emptying. This effect could be one explanation for the faster gastric emptying observed in Mexican-Americans.

There is some debate in the literature as to whether alcohol consumption actually increases or delays the rate of gastric emptying. We have found only one study examining the rate of gastric emptying of beer.[19] Pfeiffer et al[19] describe an increase in the rate of gastric emptying with beer ingestion compared with a solution containing an equivalent dose of ethanol as in the beer.[19] Others[20-23] describe a delay in gastric emptying due to alcohol (non-beer) ingestion. Charles et al[24] found that alcohol did not greatly alter postprandial motility and that it interrupted fasted motility of the small bowel to the same extent as an equicaloric sugar solution. However, alcohol ingestion did significantly alter the circadian variations in the migrating gastrointestinal motor complexes normally seen in healthy subjects. The mechanisms by which alcohol causes these motility effects have not been explained.

In our study, the gastric half-emptying time was related to the mean alcohol level ($r = -.650$, $P = .0035$) and the incremental glucose level ($r = -.709$, $P = .0010$) (Table 1). The faster the rate of gastric emptying, the higher the alcohol and glucose levels. The association of the rate of gastric emptying of beer with postconsumption blood alcohol and glucose levels has not been previously described.

In this study, we show that Mexican-Americans have faster gastric emptying of a radiolabeled beer compared with non-Hispanic whites. Mexican-Americans tend to favor beer, as opposed to wine or distilled liquors, as their alcoholic beverage of choice.[3,25] This pattern is particularly true in Mexican-American males.[3] In a recently published study, Monterrosa et al[26] found that ingestion of 100 g ethanol per week ($\approx$ 9 cans of beer) approximately doubled the risk of type II diabetes mellitus in 353 Mexican-American men. Because the carbohydrate in beer is rapidly converted to glucose after emptying from the stomach, stress is placed on the pancreas to secrete insulin to maintain glucose homeostasis. Several studies have shown that alcohol consumption is associated with hyperglycemia and insulin resistance.[27,28] The rapid gastric emptying and resultant increased blood glucose observed after ingestion of 450 mL beer suggests that this beverage may be particularly harmful to populations like Mexican-Americans, who already have an increased risk of diabetes.

Weight gain in beer drinkers is commonly recognized by the lay public, but only rarely documented in the literature.[5] Duncan et al[29] recently described the association of beer consumption and an increase in the waist to hip ratio (creating a "beer belly"). The rapid gastric emptying of alcohol-derived calories from beer may explain the decreased satiety associated with beer consumption.[30] Thus, when beer is rapidly emptied from the stomach, one is soon ready for another one. This decreased satiety may be related to weight gain in people who consume large quantities of beer. Obesity has a well-known association with the development of type II diabetes.[31-33]

Results of this study suggest that the rapid rate of gastric emptying of beer has a direct effect on resultant alcohol and glucose levels. Compared with other liquids, beer empties extremely rapidly from the stomach. In some populations, consumption of beer may result in an increased risk of development of diabetes and obesity.

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