Alcohol Use and Blood Pressure in an Unacculturated Society

Michael J. Klag, Jiang He, Paul K. Whelton, Jun-Yun Chen, Ming-Chu Qian, Guan-Qing He

Alcohol intake has been associated with higher blood pressure in acculturated populations but not in unacculturated societies. We performed a cross-sectional survey of a random community sample of 5023 male Yi rural farmers and 1656 Yi and 2173 Han men living in an urban setting. Average alcohol intake among drinkers was 36.4 g/d in Yi farmers, 56.5 g/d in Yi migrants, and 38.7 g/d in Han men. Age-adjusted mean diastolic blood pressure was 66.9, 70.5, and 71.7 mm Hg, respectively. Diastolic blood pressure was higher at higher alcohol intakes in all three groups (all P < .001). After adjustment for age, body mass index, heart rate, smoking, and physical activity, the change (95% confidence interval) in diastolic blood pressure for each standard drink was 0.50 (0.38-0.62), 0.31 (0.18-0.43), and 0.24 (0.07-0.40) mm Hg for Yi farmers, Yi migrants, and Han men, respectively. The percentage of variance in diastolic blood pressure explained by alcohol intake was 5% for Yi farmers, 4% for Yi migrants, and 2% for Han men. In a random sample of 831 men, these associations were independent of urinary sodium, potassium, calcium, and magnesium and sodium-potassium ratio. In the Yi farmers, associations were less strong for systolic blood pressure and no longer significant after adjustment. Approximately 33% of hypertension could be attributed to daily alcohol use in the Yi groups compared with 9.5% in the Han people. Alcohol use is an important contributor to elevated levels of blood pressure even in unacculturated populations with a very low average blood pressure and, in such groups, appears to affect diastolic more than systolic blood pressure. (Hypertension. 1993;22:365-370.)

Key Words • blood pressure • hypertension, alcohol-related • alcohol drinking • population studies

Alcohol use has been associated with higher blood pressure and an increased risk of hypertension in many observational studies in economically developed societies. Clinical trials have demonstrated that these associations are causal; long-term alcohol drinking raises blood pressure within a matter of weeks. All of the observational studies detailing the association between alcohol use and blood pressure have been conducted in acculturated populations with relatively high intakes of salt and low intakes of potassium. In part, this is because most unacculturated populations have low average levels of blood pressure and, in such groups, appear to affect diastolic more than systolic blood pressure.
drank almost no alcohol, leaving 5023 male Yi farmers, 1656 Yi urban residents, and 2173 Han urban residents as the study population. The sample of Yi farmers was obtained by random cluster sampling of remote mountain villages with a response rate of 85%. All Yi migrants in four cities were sampled, with a 95% response rate. The study sample of Han people was obtained by random cluster sampling of residential districts, with an 89% response rate. Completeness of the sampling was ascertained by comparison with current census data. The major reason for nonresponse in all three study groups was not being home at the time of the study.

Age, race, sex, educational level, alcohol intake, smoking, medical history, and use of antihypertensive medications were ascertained by local physicians fluent in both the Yi and Chinese languages. Usual monthly intake of wine, beer, and hard liquor was assessed in number of liang per month, where a liang is a Chinese unit of weight equivalent to 50 g. Because the local physicians indicated that the prevalence of ex-drinkers was extremely low, the questionnaire did not distinguish between nondrinkers and ex-drinkers. Alcohol consumption in grams per day was calculated by multiplying the usual monthly intake of these beverages by their alcohol content (11.6% for wine, 3.6% for beer, and 57.0% for liquor), obtained from national food tables, and dividing by 30.8 Homemade brews were not consumed.

The validity of the alcohol use questionnaire was supported by several observations. For two of the Yi farmer communities, alcohol was sold from one central store. The per capita alcohol intake for these communities for men aged 15 years and older, calculated from sales data, was 17.3 and 22.2 g/d. The average intake for men in these communities estimated by the questionnaire during the survey was 17.7 and 22.5 g/d. In addition to the close agreement with sales data for these communities, the validity of the alcohol intake data is also supported by a strong positive relation of alcohol intake with high-density lipoprotein (HDL) cholesterol, a known biochemical correlate of alcohol intake.9 In a subset of 1254 men who had their HDL cholesterol measured, HDL-C level was 0.28 mg/dL higher for every 10 g/d increment in alcohol intake (P = .01).

After a minimum of 10 minutes of quiet sitting, seated blood pressure was measured three times on the right arm and recorded to the nearest 2 mm Hg with standard mercury sphygmomanometers using World Health Organization methods.10 Systolic blood pressure was recorded at the appearance of the first sound and diastolic pressure at the disappearance of sounds (Korotkoff phase V). Blood pressure was measured by 12 specially trained physicians, 3 in each of the county seats and 3 in Sichuan City, blinded to the participants' alcohol intake. All of the observers measured blood pressure in each of the three groups: Yi farmers, Yi migrants, and Han people. Measurement technique was standardized, and quality control techniques were used. The observers were trained with training tapes from the National Heart, Lung, and Blood Institute, National Institutes of Health. After the training period, the observers were certified by comparing their blood pressure readings on 8 people (three readings per person) with those made by an experienced observer (J.H.). These analyses indicated very close agreement. During the field work, quality control was maintained by having a supervisor repeat the blood pressure measurement on a 10% random sample of subjects. If the mean of the three readings differed from the first observer by 5 mm Hg or more for either systolic or diastolic blood pressure, blood pressure determinations were repeated for all the subjects measured by that observer on that day. Height and weight were measured, and body mass index (weight [kg]/height [m]^2) was calculated as an index of obesity.11

Usual physical activity was assessed with a standardized questionnaire based on occupational activity. Level of activity by occupation was assigned based on the results of a national survey and was categorized as light, moderate, and heavy. Leisure-time activity was almost nonexistent.

To determine whether any observed association of alcohol use with blood pressure was independent of urinary electrolytes, the concentrations of sodium, potassium, calcium, magnesium, and creatinine were determined in timed overnight urine samples in a random sample of 831 men (313 Yi farmers, 265 Yi migrants, and 253 Han urban residents). Samples were obtained on 3 successive nights.12,13 A ratio of individual urinary electrolyte levels to creatinine concentration was used for the analyses.

The protocol for this study was reviewed and approved by the Chinese Academy of Medical Sciences and by the institutional review board of Peking Union Medical College. In accord with customary practice in China at the time of this study, informed consent was not obtained.

Analysis

The independent variable for this analysis was alcohol use. All analyses were performed separately for Yi farmers, migrants, and Han city dwellers. Linear regression techniques and analysis of variance were used to test the association of alcohol intake with blood pressure. Alcohol intake was analyzed both as a continuous variable, grams of absolute alcohol per day, and as a categorical variable. Categories of alcohol intake were nondrinkers, less than 30, 30 to 74, and greater than or equal to 75 g/d. Results of the linear regression analyses using alcohol intake as a continuous variable were expressed as the change in blood pressure for a daily intake of one standard drink, approximately 12 g or 15 mL of alcohol.14 Hypertension was defined as an average systolic blood pressure of 140 mm Hg or higher, diastolic blood pressure of 90 mm Hg or higher, and/or the use of antihypertensive medication. Logistic regression analysis was used to estimate the risk of hypertension associated with an average daily intake of one standard drink and to calculate the prevalence of hypertension adjusted for the mean level of covariables in the three groups combined. The attributable risk of hypertension associated with daily alcohol use was also calculated.15

To account for a possible community effect, data from all three groups were combined and regressions stratified by the 14 communities. Pooled regression coefficients were calculated after weighting by the inverse of the variance.16 Probability values were based on two-tailed tests.
Results

Table 1 shows the characteristics of the study population. Mean age varied among the different groups, with Yi farmers being the youngest. The average alcohol intake in grams per day among drinkers was lowest for the Yi farmers and highest for the Yi migrants. Average alcohol intake for the Yi migrants was more than four times greater than that for the Yi farmers and highest for the Yi migrants. Average alcohol intake was also evident when alcohol consumption was analyzed as a continuous variable. The change in systolic and diastolic blood pressures associated with a 12 g/d increase in alcohol intake was displayed in Table 2. Univariate analysis showed that the rise in systolic blood pressure with greater levels of alcohol intake was present in all three groups but was greatest in the Han people. For diastolic blood pressure, however, the increase in blood pressure with increasing alcohol intake was significantly greater for the Yi farmers than for the other two groups. Similar results were seen with a multivariate analysis (Fig 1, Table 3). After adjustment for age, body mass index, heart rate, smoking, and physical activity, the change in systolic blood pressure with increasing levels of alcohol intake among the Yi farmers was markedly reduced and no longer statistically significant. In the other two groups, the increase in systolic blood pressure was reduced by half but remained statistically significant. In all three groups, multivariate analysis showed that alcohol use was independently associated with diastolic blood pressure. The rise in diastolic blood pressure with higher alcohol intake, after adjustment, was twice as great in the Yi farmers as in the other two groups. The percent variance in diastolic blood pressure explained by alcohol intake was 5% for Yi farmers, 4% for Yi migrants, and 2% for Han men.

In the 831 men with urinary electrolyte information, the mean overnight (8-hour) sodium excretion was 34.3 mmol in the Yi farmers, 40.3 mmol in the Yi migrants, and 45.1 mmol in the Han people. These values are equivalent to 24-hour excretions of 105, 172, and 183 mmol, respectively.17 For potassium, the average overnight excretion was 19.4, 7.1, and 6.0 mmol for Yi farmers, migrants, and Han people, respectively.17 The association of alcohol use with blood pressure persisted after additional adjustment for urinary concentration of sodium, potassium, and calcium as well as for the variables listed in Table 3. The change in blood pressure associated with daily intake of a standard drink in this multivariate model was 0.25 mm Hg for systolic pressure (95% confidence interval [CI], 0.00-

### Table 1. Characteristics of Study Population

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Yi farmers</th>
<th>Yi migrants</th>
<th>Han people</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>5023</td>
<td>1656</td>
<td>2173</td>
</tr>
<tr>
<td>Mean age (y)</td>
<td>30.9 (0.20)</td>
<td>34.8 (0.32)</td>
<td>36.9 (0.29)</td>
</tr>
<tr>
<td>Mean alcohol intake (g/d)*</td>
<td>36.4 (0.70)</td>
<td>56.5 (1.80)</td>
<td>38.7 (1.30)</td>
</tr>
<tr>
<td>Mean body mass index (kg/m²)</td>
<td>20.6 (0.03)</td>
<td>21.3 (0.06)</td>
<td>21.0 (0.05)</td>
</tr>
<tr>
<td>Mean SBP (mm Hg)</td>
<td>110.8 (0.17)</td>
<td>113.0 (0.34)</td>
<td>114.5 (0.31)</td>
</tr>
<tr>
<td>Increase with age (mm Hg/y)</td>
<td>0.13 (0.01)</td>
<td>0.33 (0.03)</td>
<td>0.36 (0.02)</td>
</tr>
<tr>
<td>Mean DBP (mm Hg)</td>
<td>66.3 (0.17)</td>
<td>70.9 (0.28)</td>
<td>72.6 (0.22)</td>
</tr>
<tr>
<td>Increase with age (mm Hg/y)</td>
<td>0.23 (0.01)</td>
<td>0.33 (0.02)</td>
<td>0.23 (0.02)</td>
</tr>
<tr>
<td>Mean heart rate (bpm)</td>
<td>74.9 (0.13)</td>
<td>74.7 (0.21)</td>
<td>76.2 (0.17)</td>
</tr>
<tr>
<td>Physical activity (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light</td>
<td>0.8 (0.13)</td>
<td>63.1 (1.19)</td>
<td>49.8 (1.07)</td>
</tr>
<tr>
<td>Moderate</td>
<td>1.9 (0.19)</td>
<td>30.0 (1.13)</td>
<td>34.4 (1.02)</td>
</tr>
<tr>
<td>Heavy</td>
<td>97.3 (0.23)</td>
<td>69.0 (0.62)</td>
<td>15.8 (0.78)</td>
</tr>
<tr>
<td>Smoking (%)</td>
<td>64.1 (0.68)</td>
<td>71.3 (1.11)</td>
<td>72.9 (0.95)</td>
</tr>
</tbody>
</table>

SBP, systolic blood pressure; DBP, diastolic blood pressure; *Among drinkers.

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### Table 2. Mean Systolic and Diastolic Blood Pressures by Alcohol Consumption Levels

<table>
<thead>
<tr>
<th>Alcohol consumption (g/d)</th>
<th>Yi farmers</th>
<th>Yi migrants</th>
<th>Han people</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>SBP (mm Hg)</td>
<td>DBP (mm Hg)</td>
<td>SBP (mm Hg)</td>
</tr>
<tr>
<td>0</td>
<td>2348</td>
<td>109.4 (0.25)</td>
<td>63.6 (0.26)</td>
</tr>
<tr>
<td>≤30</td>
<td>1690</td>
<td>111.4 (0.30)</td>
<td>67.5 (0.27)</td>
</tr>
<tr>
<td>30-74</td>
<td>712</td>
<td>113.1 (0.47)</td>
<td>70.3 (0.38)</td>
</tr>
<tr>
<td>≥75</td>
<td>273</td>
<td>113.5 (0.71)</td>
<td>72.5 (0.61)</td>
</tr>
<tr>
<td>P (ANOVA)</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

SBP, systolic blood pressure; DBP, diastolic blood pressure; ANOVA, analysis of variance. Values are mean (SEM).
TABLE 3. Change in Blood Pressure With 12 g/d Increase in Alcohol Intake in Univariate and Multivariate Regression Analyses

<table>
<thead>
<tr>
<th>Group</th>
<th>SBP (mm Hg) Univariate</th>
<th>Multivariate*</th>
<th>DBP (mm Hg) Univariate</th>
<th>Multivariate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yi farmers</td>
<td>0.44 (0.31, 0.56)</td>
<td>0.11 (-0.02, 0.24)</td>
<td>0.94 (0.82, 1.07)</td>
<td>0.50 (0.38, 0.62)</td>
</tr>
<tr>
<td>Yi migrants</td>
<td>0.46 (0.30, 0.62)</td>
<td>0.28 (0.12, 0.43)</td>
<td>0.49 (0.36, 0.62)</td>
<td>0.31 (0.18, 0.43)</td>
</tr>
<tr>
<td>Han people</td>
<td>0.69 (0.44, 0.93)</td>
<td>0.36 (0.13, 0.59)</td>
<td>0.46 (0.31, 0.65)</td>
<td>0.24 (0.07, 0.40)</td>
</tr>
</tbody>
</table>

SBP, systolic blood pressure; DBP, diastolic blood pressure; CI, confidence interval.
*Adjusted for age, body mass index, heart rate, smoking, and physical activity.

The relation of alcohol use to blood pressure was also seen in analyses stratified by community. The increase in blood pressure for a daily drink of 12 g alcohol, calculated from the pooled regression coefficient, was 0.47 mm Hg (95% CI, 0.36-0.57) for systolic and 0.58 mm Hg (0.47-0.69) for diastolic blood pressure.

Alcohol Use and Hypertension

The prevalence of hypertension, as previously defined, was 2.7% in the Yi farmers, 9.6% in the Yi migrants, and 9.5% in the Han people. The prevalence of antihypertensive medication use was low; none of the Yi farmers, 0.4% of the migrants, and 1.2% of the Han people were taking medications for high blood pressure. The prevalence of hypertension rose in a stepwise fashion with increasing alcohol intake in the Yi farmers and Yi migrants. In the Han people, the prevalence of hypertension was very similar in nondrinkers and in those who drank less than 30 g/d. The pattern of higher prevalence of hypertension at higher levels of alcohol intake persisted after adjustment for all of the variables listed in Table 3 (Fig 2). Univariate analysis showed that a 12 g/d greater alcohol intake imparted a 7% to 9% increased risk of hypertension (Table 4). After adjustment for other factors, this risk fell to 1% to 6% and was no longer significant in the Han. The percentage of hypertension that could be attributed to daily alcohol use was 33.3% for the Yi farmers, 33.4% for the migrants, and 9.5% for the Han people.

Discussion

Little has been written regarding the relation of alcohol use to blood pressure in unacculturated groups. A previous study of the Yi people did not have an adequate sample size to address this issue. The four low-salt, high-potassium intake populations included in the INTERSALT study either did not drink or consumed very low levels of alcohol. Thus, the present study is unique in offering an opportunity to examine the relation of alcohol use to blood pressure in such a population. Alcohol use was associated with higher blood pressure and a greater risk of hypertension in the most unacculturated group—Yi farmers—as well as in the more acculturated urban dwellers—Yi migrants and Han people. Analyses stratified by community produced consistent results, demonstrating that the relation between blood pressure and alcohol use was not due to differences among communities. Because no informa-
was lower, however, in the Yi migrants and Han people populations has not been reported in the English literature.

Mean levels of systolic and diastolic blood pressures and body mass index in the Han men in the present study were similar to those of men in Guangzhou, Southern China, but lower than those of men in Beijing who participated in the People’s Republic of China–United States collaborative study. Smoking prevalence in the Yi migrants and Han urban dwellers was also similar to that reported for the men in Guangzhou. These similarities support the generalizability of our findings to the general population of southern China. Compared with four remote populations in the INTERSALT study, the estimated 24-hour sodium excretion was much higher in the three groups in the present study. Estimated 24-hour potassium excretion in the Yi farmers was similar to the Xingu Indians of Brazil (96 mmol/24 h) but much higher than the other INTERSALT remote populations. Potassium excretion was lower, however, in the Yi migrants and Han people than in three of the four INTERSALT groups.

As far as we are aware, the relation of alcohol use to blood pressure and risk of hypertension in Chinese populations has not been reported in the English literature. Comparisons with other reports are hampered because studies collect alcohol intake information in various ways. Although biologic differences in the metabolisms of alcohol exist between Asian and Caucasian populations, the present study demonstrates a pressor effect of alcohol in Han people similar to that seen in observational studies of Western populations. These results are consistent with a direct comparison study of Japanese men and Caucasian men, in which the quantitative relation of alcohol use to blood pressure among drinkers was very similar between the two groups. In the Kaiser-Permanente Study, the difference in blood pressure between nondrinkers and those consuming six or more drinks a day (approximately 72 g alcohol) was 10.9 mm Hg for systolic blood pressure and 4.5 mm Hg for diastolic. In the Maryland Household Hypertension Survey, men aged 18 to 49 years who drank more than two drinks (approximately 24 g) a day had a 1.2 mm Hg higher systolic blood pressure and 0.8 mm Hg higher diastolic blood pressure than nondrinkers. This difference is similar to the gradient between Han men in the present study who drank 30 g or less a day and nondrinkers. Studies in acculturated populations also consistently show a greater pressor effect of alcohol intake on systolic than diastolic blood pressure.

In the unacculturated group in the present study, however, a greater effect of alcohol drinking on diastolic blood pressure was seen. Yi migrants demonstrated an intermediate pattern, suggesting that this dissimilarity between Yi farmers and Han men was not due to random variation but may represent a characteristic of unacculturated groups. Systematic differences between observers could not account for the observed differences among the three groups studied because all of the observers measured blood pressure in each of the three groups. This result requires confirmation in future studies of unacculturated populations.

The relation between alcohol use and blood pressure was linear in both the unacculturated and acculturated groups in the present studies. In some populations, however, average blood pressure is lower at low levels of alcohol intake than in abstainers—a so-called J-shaped relation. In American men, there is evidence suggesting that this J shape may be due to underreporting of heavy alcohol intake by self-described nondrinkers. The higher blood pressure in nondrinkers has also been suggested to be due to the inappropriate lumping of lifelong nondrinkers with ex-drinkers, who may have stopped drinking because of the diagnosis of high blood pressure or other cardiovascular disease. No information was available on ex-drinkers in the present study. Because this was the first time in their lives that the Yi farmers had their blood pressure measured, however, it is unlikely that there was any systematic bias between alcohol intake and blood pressure. In addition, the lack of a J-shaped relation between blood pressure and drinking in the present study argues against underreporting of heavy alcohol use in these groups.

The mechanism by which alcohol drinking raises blood pressure is uncertain. An action of alcohol intake on the renin-angiotensin system, cortisol secretion, entry of calcium into vascular smooth muscle, and the sympathetic nervous system have all been suggested as possibilities. The demonstration of an association of alcohol use with blood pressure in the Yi farmers...
indicates that this pressor effect is not dependent on other factors, such as high-sodium or low-potassium diets or obesity, associated with the greater prevalence of hypertension in acculturated populations. These findings indicate that, in unacculturated groups with a low average blood pressure, alcohol use is an important contributor to elevated levels of blood pressure.

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