Relationship between Blood Pressure and Alcohol Consumption on the Previous Day in Japanese Men

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An association has been found between high blood pressure (BP) and the regular consumption of alcohol in epidemiological studies, and a repeated withdrawal reaction to alcohol is considered one of the mechanisms of high BP in drinkers. In this study, we investigated the association between BP and alcohol consumption on the previous day in regular male drinkers. The study participants were 551 men aged 20 to 59 yr who drank alcohol regularly. BP was measured and information on daily alcohol intake was obtained from each participant by a questionnaire, which also asked whether alcohol had been consumed on the day before BP measurement. Age-adjusted BP was compared between participants who had ($n=504$, 91.6%) and those who had not ($n=47$, 8.4%) consumed alcohol on the previous day. There were no significant differences between the two groups with regard to BP or body mass index. Even after excluding subjects who were receiving anti-hypertensive drugs, there was still no significant difference in age-adjusted BP between the two groups. Our study found no association between BP and alcohol consumption on the previous day in regular male drinkers, which implies that alcohol withdrawal after 1 d of abstinence cannot explain the high blood pressure found in regular drinkers in this Japanese middle-aged population. (*Hypertens Res* 1998; 21: 175-178)

Key Words: alcohol, blood pressure, epidemiology, mechanism

A positive association has been found between high blood pressure (BP) and the regular consumption of alcohol in various epidemiological and clinical studies in different populations (1-5). This association persists even after adjusting for the effect of confounding factors such as age, body mass index (BMI), and dietary habits (6, 7). The mechanism by which alcohol increases BP is not clearly understood. Some studies have suggested that the high BP found in heavy drinkers is due to repeated withdrawal from alcohol during detoxification (8, 9), and this has been supported by the observation that BP after 12 h of fasting was more closely associated with alcohol consumed in the previous 24 h than with alcohol consumed in the previous week (2). However, this hypothesis has not yet been tested in a population-based study of Japanese subjects, who have a high prevalence of deficiency in an isoenzyme of aldehyde dehydrogenase (ALDH2) that is required for alcohol metabolism (10). In this study, we investigated the association between BP and the consumption of alcohol on the previous day in regular male drinkers. We hypothesized that if alcohol increased blood pressure through some mechanism involving withdrawal, then a subject who did not drink the day before the examination should have a higher BP than one who drank alcohol the day pre-

ceding BP measurement.

Subjects and Methods

A total of 1409 male, white-collar employees of a life insurance company in Tokyo, aged 20 to 59 yr, were surveyed by a questionnaire at the time of their annual health examination in 1984. Overall, 883 employees returned the questionnaire, for a response rate of 62.6%. The questionnaire included questions on the kind of alcoholic beverages consumed, the usual quantity consumed per d and the frequency of alcohol consumption per wk and mo. For drinkers, the questionnaire asked whether or not the subject had consumed alcohol yesterday, *i.e.*, the day before the health examination.

Public health nurses interviewed each participant and simultaneously reviewed the questionnaire. The participant's intake of *sake*, beer, whisky, and other alcoholic beverages was scored in terms of the number of *go* (a traditional Japanese unit of volume, 1 *go* = 180 ml) of *sake*, bottles of beer (663 ml/bottle), or two single shots of whisky (70 ml). The total daily intake was then converted to pure alcohol equivalents.

Blood pressure was measured by public health nurses with the subject sitting after a 5-min rest, us-

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Table 1. Body Mass Index (BMI), Systolic (SBP) and Diastolic (DBP) Blood Pressure and Alcohol Consumption per Day According to 10-Year Age Groups in Almost-Daily Drinkers (Means $\pm$ SD)

	Age group (yr)				* <i>p</i>
	20-29	30-39	40-49	50-59	
<i>n</i>	64	161	175	151	
BMI (kg/m ²)	22.8 $\pm$ 2.7	22.6 $\pm$ 2.6	22.9 $\pm$ 2.8	23.0 $\pm$ 2.3	0.501
SBP (mmHg)	125.8 $\pm$ 12.0	123.8 $\pm$ 11.3	127.6 $\pm$ 15.5	132.3 $\pm$ 14.6	<0.001
DBP (mmHg)	79.4 $\pm$ 7.8	81.0 $\pm$ 9.0	84.8 $\pm$ 10.7	86.6 $\pm$ 9.1	<0.001
Alcohol (ml/d)	54.7 $\pm$ 40.6	48 $\pm$ 27.2	56.3 $\pm$ 25.8	53.2 $\pm$ 25.7	0.056

n, number of subjects. **p* value is for trend by analysis of variance.

Table 2. Age, BMI, SBP, DBP, Alcohol Intake per Day, and Serum γ GTP According to Tertiles of Daily Alcohol Consumption (Means $\pm$ SD) in Almost-Daily Drinkers

	Tertile 1	Tertile 2	Tertile 3	* <i>p</i>
	0<DAC<30 (ml/d)	30 $\leq$ DAC<59 (ml/d)	59 $\leq$ DAC $\leq$ 72 (ml/d)	
<i>n</i>	187	191	173	
Alcohol (ml/d)	27.3 $\pm$ 4.1	46.8 $\pm$ 7.0	63.0 $\pm$ 5.8	
Age (yr)	40.1 $\pm$ 9.7	43.8 $\pm$ 9.5	42.2 $\pm$ 9.1	<0.001
BMI (kg/m ²)	22.4 $\pm$ 2.4	23.0 $\pm$ 2.6	23.0 $\pm$ 2.8	0.02
SBP (mmHg)	124.2 $\pm$ 14.0	128.1 $\pm$ 14.5	130.7 $\pm$ 14.2	<0.001
DBP (mmHg)	81.6 $\pm$ 9.8	83.9 $\pm$ 10.1	85.4 $\pm$ 9.1	0.001
γ GTP (u/l) [#]	38.0 $\pm$ 51.0	49.2 $\pm$ 51.2	66.0 $\pm$ 62.7	<0.001

Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; γ GTP, gamma glutamyl transpeptidase; DAC, daily alcohol consumption. **p* value is for trend. [#] γ GTP was measured in 417 subjects. Values are means $\pm$ SD.

Table 3. Age- and BMI-Adjusted SBP and DBP According to Tertiles of Daily Alcohol Consumption after Exclusion of Subjects Receiving Antihypertensive Drugs

	Tertile 1	Tertile 2	Tertile 3	* <i>p</i>
	0<DAC<30 (ml/d)	30 $\leq$ DAC<59 (ml/d)	59 $\leq$ DAC $\leq$ 72 (ml/d)	
<i>n</i>	172	166	152	
SBP (mmHg)	124.0 $\pm$ 1.0	125.8 $\pm$ 1.0	129.5 $\pm$ 1.1	0.001
DBP (mmHg)	81.4 $\pm$ 0.7	82.0 $\pm$ 0.7	84.5 $\pm$ 0.7	0.003

Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; DAC, daily alcohol consumption. **p* value is for trend. Values are means $\pm$ SEM.

ing a standard sphygmomanometer, to the nearest 2 mmHg, on the right arm, with Korotkoff phases I and V being taken as systolic (SBP) and diastolic (DBP) blood pressure, respectively. Weight was measured with the subject wearing a light cloth, and height was measured with the subject standing. BMI was calculated as weight (kg)/[height (m)]². Blood was drawn in the morning after an overnight fast, and serum gamma glutamyl transpeptidase (γ GTP) was measured.

A total of 551 participants either drank daily or 5 to 6 d per wk and were identified as regular drinkers and grouped together as almost-daily drinkers. These subjects were selected for analysis in this study. Participants were classified into tertiles according to daily alcohol intake, and BP levels were compared among the groups. The BP of parti-

cipants who drank alcohol on the day preceding BP measurement was compared with that of participants who did not drink on the day preceding BP measurement.

An analysis of variance (ANOVA) was used to compare the means of the groups, while adjusting for age and BMI by covariate analysis. A *p* value < 0.05 for F statistics was considered to indicate statistical significance.

Results

Age group-specific BMI, SBP, DBP, and daily alcohol intake in almost-daily drinkers are shown in Table 1. Both SBP and DBP increased with age. Table 2 shows age, BMI, SBP, DBP, alcohol intake per d, and serum γ GTP in the tertiles of daily alco-

Table 4. Mean and Standard Deviation of Some Selected Variables in the Almost-Daily Drinkers According to the Yesterday-Drink Response and in All Subjects

	Yesterday drink		All
	"Yes"	"No"	
<i>n</i>	504 (91.6%)	47 (8.4%)	551 (100%)
Age (yr) *	42.3±9.5	39.4±9.8	42.0±9.5
SBP (mmHg)	127.6±14.5	127.0±14.4	127.9±14.4
DBP (mmHg)	83.7±9.7	82.5±10.8	83.6±10.8
BMI (kg/m ²)	22.8±2.6	22.6±2.6	22.8±2.6
γGTP# (u/l)	51.5±55.4	53.7±66.9	51.6±56.2
Alcohol (ml/d)	52.9±26.3	52.3±45.3	52.8±28.4

Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; γGTP, gamma glutamyl transpeptidase. * $p < 0.052$, #γGTP was measured in 417 subjects. Values are means±SD.

Table 5. Age Adjusted* SBP and DBP in Almost-Daily Drinkers According to the Yesterday-Drink Response after Exclusion of Subjects Receiving Antihypertensive Drugs

	Yesterday drink		<i>p</i>
	"Yes"	"No"	
<i>n</i>	449	41	
SBP (mmHg)	126.2±0.7	127.1±2.2	0.700
DBP (mmHg)	82.6±0.4	82.6±1.4	0.956

* Adjustment was done by analysis of covariance. Values are means±SEM. *n*, numbers of subjects.

hol consumption. Both SBP and DBP were significantly higher in the groups with higher alcohol consumption ($p < 0.001$ and $p = 0.001$, respectively). Age and BMI were also significantly associated with alcohol consumption. Age- and BMI-adjusted SBP and DBP after excluding subjects who were receiving antihypertensive drugs were significantly higher in the groups with higher alcohol consumption ($p = 0.001$ and $p = 0.003$, respectively) (Table 3).

Among the regular drinkers, 504 (91.6%) participants reported that they had consumed alcohol on the day before BP measurement (yesterday-drinker), while 47 participants (8.4%) reported that they had not consumed alcohol on the day before BP measurement (non-yesterday drinker). There were no significant differences in SBP, DBP, or BMI between the two groups, while age was lower in non-yesterday drinkers (Table 4). Even after excluding subjects on anti-hypertensive drugs, there was still no significant difference in age-adjusted mean SBP and DBP between the two groups (Table 5).

Discussion

In this study, both SBP and DBP were positively

associated with daily alcohol consumption, and BP in regular drinkers was not associated with alcohol consumption on the previous day.

The positive association between BP and alcohol consumption found in our study is consistent with the results of previous cross-sectional studies (1, 3, 7) and has been well-established by randomized intervention trials (5). Since there was no difference in BP between yesterday drinkers and non-yesterday drinkers in our study, the higher BP in regular moderate drinkers might not be due to withdrawal, as postulated in several previous studies (8, 9). Our result is consistent with that of Potter and Beevers (4). However, our study has certain limitations that should be kept in mind before forming any definite conclusions. Since this study was population-based and alcohol-related, the data on alcohol consumption may be inaccurate owing to underreporting. Although serum γGTP, a biochemical marker of alcohol consumption, was measured, other biochemical markers, such as serum catecholamines and their urinary metabolites, plasma cortisol level, and plasma renin activity, were not measured. In our study, we grouped subjects according to whether they had consumed alcohol on the previous day, but the time from the last drink to BP measurement was not noted. A recent study by Abe *et al.* indicated that both the depressor and pressor effects of alcohol on BP vary according to the time between the last drink and BP measurement (11). In our study, we did not identify subjects who were deficient in ALDH2 enzyme; therefore, the association between BP and alcohol consumption on the previous day was not adjusted for by the presence of ALDH2 enzyme. However, Okayama *et al.* reported that inactive ALDH2 is probably unrelated to the elevation of BP due to alcohol intake in their study of Japanese subjects (12).

Abe *et al.* (11) suggested that a direct slow pressor mechanism may play a role in the elevation of BP by alcohol, while others reported that high BP is mediated by direct effects of alcohol on neural, humoral, and renal pressor mechanisms (4, 13, 14). Some studies have examined the role of hormones in the pressor effect of alcohol. Ireland *et al.* observed an acute increase in BP and circulating plasma norepinephrine after alcohol ingestion in normotensive men (13). Potter and Beevers (4) found that plasma cortisol levels increased during alcohol consumption, and Ueshima *et al.* (15), in their randomized controlled study, found that the cortisol level in subjects with low alcohol consumption was lower than that in a control group with moderate alcohol consumption. On the other hand, Arkwright *et al.* reported that although BP was higher in drinkers, there were no significant differences in plasma epinephrine, norepinephrine, cortisol level, or renin activity between drinkers and non-drinkers (16). Further studies of the roles of these pressor substances in the pressor effect of alcohol are needed to clarify these inconsistencies. Animal studies have drawn attention to the possibility that chronic alcohol consumption might be directly related to peripheral vascular tone and

vascular smooth muscle calcium transport (17). These hypotheses require further investigation in humans.

In conclusion, our study did not find any association between BP and alcohol consumption on the previous day in regular male drinkers, which implies that alcohol withdrawal after 1 d of abstinence cannot explain the high blood pressure found in regular male drinkers in this Japanese middle-aged population.

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