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Characteristics of Coronary Heart Disease in Japanese Taxi Drivers as Determined by Coronary Angiographic Analyses

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Abstract: Several epidemiological studies have shown that the prevalence of ischemic heart disease is higher in occupational drivers than in people with other occupations. Although occupation categories can be surrogate measures for coronary risk factors, the relationships between taxi driving and severity of coronary heart disease (CHD) has not been investigated. Even more important, the contribution of risk factors to the severity of CHD in taxi drivers remains unclear. Our study tested the hypothesis that taxi driving could be associated with the severity of CHD. We also examined the relation between this occupation and risk factors and social lifestyle. We analyzed the coronary angiograms of 57 consecutive male taxi driver patients and compared them with those of 215 age-adjusted male non-taxi-driver patients. The number of diseased vessels and risk factors were compared between two groups. The prevalence of myocardial infarction and multi-vessel disease was higher in the taxi-driver patients than in the non-taxi-driver patients. The taxi-driver patients had higher prevalence of body mass index (BMI), diabetes, and smoking, higher levels of low-density lipoprotein cholesterol (LDL-C), and lower levels of apolipoprotein AI (ApoAI). Multiple logistic regression analysis showed that multi-vessel disease was associated with BMI and diabetes mellitus in taxi-driver patients. The taxi-driver patients were characterized by more extensive coronary atherosclerosis associated with higher prevalence of diabetes mellitus and obesity. These characteristics may be explained by in part their working environment.

Key words: Occupational health, Taxi Drivers, Coronary heart disease, Coronary angiography, Coronary risk factors

Introduction

Several epidemiological studies have shown that the prevalence of ischemic heart disease (IHD) is higher in occupational drivers than in people with other occupations[1–11]. According to a 1990 occupational report from the Statistics and Information Department in Minister's Secretariat of Ministry of Health and Welfare of Japan in which the age-adjusted mortality rate from four major causes was calculated for men older than 15 in different professions, the mortality rate from heart disease was highest for workers in the transportation and communication industry[12]. Previous studies had shown that the risk of ischemic heart disease and the associated mortality rate was higher in Japanese

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taxi drivers than in Japanese with other occupations[13–19].

Coronary angiography (CAG) is a useful tool for diagnosing and evaluating the severity of coronary artery disease. A strong correlation between coronary risk factors and CAG findings has been established[20–26]. Although occupation categories can be surrogate measures for coronary risk factors, the relationship between taxi driving and severity of CHD, as determined angiographically, has not been investigated. Even more important, the contribution of coronary risk factors to the severity of CHD in taxi drivers remains unclear. Our study tested the hypothesis that taxi driving would be associated with the severity of coronary heart disease. We have also examined the relation between this occupation and coronary risk factors and social lifestyle.

Materials and Methods

Patient selection

We reviewed the records of all patients who underwent coronary angiography for symptoms of IHD at Juntendo University hospital between January 1, 1993, and December 30, 1997. To be included in the study, the patients had to meet the following criteria: (1) male workers aged between 45 and 60 years, (2) significant luminal narrowing (>75% narrowing in at least one major coronary artery), (3) HMG-Co enzyme inhibitors, probucol or fibrate drugs had not been administered, or if these drugs had been administered before CAG, biochemical tests before medication were performed on a date within six months of the CAG. The exclusion criteria were (1) prior coronary intervention (angioplasty or coronary bypass); (2) treatment by thrombolysis or angioplasty; (3) coronary angiogram unsuitable for analysis; (4) patients unable to provide a clear clinical history and data. Of a total of 3,729 patients (3,081 men of ages ranging from 21 to 91 years, and 648 women of ages ranging from 25 to 86 years), 57 male taxi drivers and 215 male workers in other professions (non-taxi-drivers) with matching ages were included in this study. Of the aforementioned 57 taxi drivers, 49 workers with verifiable career records had an average of 18.57 years of professional driving experience (ranging from 3–36); the remaining 8 workers did not have verifiable career records.

The high prevalence of taxi drivers in this population could be explained by the fact that those taxi driver patients were referred to us by a health insurance union for occupational drivers in Tokyo.

In the occupational classification system used for the 1995 national census, ten occupational groups were established. The breakdown of the non-taxi-driver patients was as follows: 16.3% of the patients had technical jobs, 17.2% had managerial jobs, 27.0% had clerical jobs, and 13.5% had sales jobs, and 26% had other occupations. None of the patients worked in the agriculture, forestry, or fishery industry. Taxi drivers included both self-employed taxi drivers and employees of private taxi companies, but eight occupational drivers (trucks, delivery vans, etc.) were classified as belonging to the non-taxi-driver group.

Coronary angiography (CAG)

After administering 0.5–1 mg of isosorbide dinitrate into the coronary arteries, multi-directional angiography was performed in the conventional manner (cineangio-cardiography). Coronary arteriosclerotic lesions were assessed by dividing the coronary arteries into 15 segments according to the American Heart Association Grading Committee[27]. Two skilled angiographers discussed and assessed the degree of luminal narrowing. Significant disease was defined as a 75% or greater luminal narrowing of at least one major coronary artery. Then, the subjects were classified into three subgroups depending on the number of diseased vessels: one-vessel diseased (1VD) group, two-vessel diseased (2VD) group and three-vessel diseased (3VD) group. Also, 50% narrowing in the left main coronary trunk (LMT) was considered significant, and stenosis of the left coronary artery was classified as two-vessel disease. The group consisting of the 2VD and 3VD groups was referred to as the multivessel disease (MVD) group.

Coronary risk factors and social factors

The following parameters were statistically compared between taxi drivers and non-taxi-drivers.

1) Hypertension: According to the standards established in the Fifth Report published by the American Hypertension Association (JNC-V)[28], patients were diagnosed as having hypertension if antihypertensive drugs were prescribed, systolic blood pressure was more than 140 mmHg, or diastolic blood pressure was more than 90 mmHg.

2) Diabetes mellitus: Patients were diagnosed as having diabetes mellitus if they had received diabetes therapy, had fasting blood sugar level of more than 140 mg/dl or casual blood sugar level of more than 200 mg/dl, or tested positive for diabetic pattern to a 75-g oral glucose tolerance test.

3) Smoking: Smokers were defined as those who had smoked more than 20 cigarettes a day for at least five years, and heavy smokers as those who had smoked more than 40 cigarettes a day for at least five years in this study.

4) Obesity: Body mass index (BMI) was calculated as body weight divided by height square. According to the Japanese Obesity Association Standards, patients with a BMI of greater than or equal to 26.4 were defined as obese.

5) Biochemical data: A blood sample was collected while patients were fasting to measure the levels of the following compounds: Total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C=TC-HDL-TG/5)[29], apolipoprotein AI (ApoAI), apolipoprotein B (ApoB), apolipoprotein E (ApoE), lipoprotein (a) [Lp(a)], uric acid (UA), fasting blood sugar (FBS), and hemoglobin A_{1c} (HbA_{1c}).

6) Social factors

Patients were asked: 1) whether they were married and 2) whether they were divorced.

Number of risk factors

The number of the following typical coronary risk factors was counted in each patient: hypercholesteremia (TC of more than 220 mg/dl), diabetes mellitus, hypertension, smoking, and obesity.

Statistics

The following three types of analyses were performed.

1) Single-variate analysis between taxi drivers and non-taxi-drivers.

2) Single-variate analysis between single and multiple vessel disease groups for both taxi drivers and non-taxi-drivers.

3) Multivariate analysis based on multivessel disease (dependent variables) for both taxi drivers and non-taxi-drivers.

A chi-square test was used to compare the ratio of the following eight factors: history of myocardial infarction, number of affected arteries, diabetes mellitus, hypertension, smoking, marital status, divorce, and having more than three risk factors. Average age, BMI, serum lipid levels and UA were statistically analyzed by an unpaired *t*-test (a total of 11 parameters). P values of less than 5% were considered significant. A multivariate logistic regression analysis was used to assess the relationship between multivessel disease and each risk factor. With respect to the independent variables involved in multi-variate analysis, the numeral 1 (one) was assigned to the positive cases of the four history variables (diabetes mellitus, hypertension, smoking and divorce)—and zero was assigned to the negative cases. For other variables (Age, BMI, serum lipid levels and UA) the actual numbers were used. The above statistical analyses were performed using the medical statistics software package Statistical Analysis System (SAS)[30].

Results

Characteristics of taxi drivers and non-taxi-drivers

Table 1 shows the profile of the taxi-driver and non-taxi-driver patients. BMI was higher for taxi drivers than for non-taxi-drivers, and the ratios of myocardial infarction, diabetes mellitus, smoking, unmarried status and divorce were significantly higher for taxi drivers. There was a significant difference in the ratio of heavy smokers between taxi drivers and non-taxi- drivers. Ninety-three percent of the taxi-driver patients smoked more than 20 cigarettes a day and 56.1% of them smoked more than 40 cigarettes a day, but only 30.7% of the non-taxi-driver patients smoked more than 40 cigarettes a day. The total ratio of patients with 3, 4, or 5 factors was 61.4% for taxi drivers and 30.2% for non-taxi drivers, and there was a significant difference between the two groups.

As regards serum lipid levels, there were significant differences in the levels of LDL-C and Apo AI between taxi drivers and non-taxi-drivers. Also, although there were no statistically significant differences, the levels of TC and Lp (a) were higher and the level of HDL-C was lower for taxi drivers.

To investigate the accumulation of coronary risk factors in individual patients, the number of typical coronary risk factors for each patient was counted. Figure 1 shows the distribution of the patients with 0 to 5 risk factors. The taxi drivers tend to have more risk factors than non-taxi-drivers.

Coronary angiographic findings

Figure 2 shows the breakdown of the number of diseased vessels for taxi drivers and non-taxi- drivers. More than one coronary artery was affected in 63.2% of the taxi-driver patients, and in 48.4% of the non-taxi-driver patients ($p=0.0471$). In particular, the ratio of patients with 3VD was significantly higher for taxi drivers (35.1%) than for non-taxi-drivers (15.3%) ($p=0.0008$). The LMT was affected in 10.5% of the taxi-driver patients and 8.3% of the non-taxi-driver patients.

Factors related to multiple vessel disease

Table 2 shows the results of single-variate analyses between single and multiple vessel disease groups for both taxi drivers and non-taxi-drivers. In taxi drivers, there were

Table 1. Comparison of characteristics between taxi drivers and non-taxi-drivers

	taxi drivers N=57	non-taxi-drivers N=215	p-value
Age (year)	54.1 ± 4.3	54.2 ± 4.4	ns
Myocardial infarction (%)	68.4	49.3	0.01
BMI (kg/m^2)	25.4 ± 3.6	24.4 ± 3.0	0.03
Diabetes mellitus (%)	50.9	27.4	<0.001
Hypertension (%)	57.9	53.0	ns
Smoking* (%)	93.0	70.2	<0.001
Unmarried (%)	31.6	12.6	<0.001
Divorce (%)	26.3	6.1	<0.0001
Having more than 3 risk factors (%)	61.4	30.2	<0.0001
TC (mg/dl)	218.1 ± 50.1	204.5 ± 37.4	0.06
TG (mg/dl)	178.3 ± 78.1	167.0 ± 83.6	ns
HDL-C (mg/dl)	39.1 ± 9.8	41.8 ± 12.3	0.08
LDL-C (mg/dl)	143.4 ± 41.2	129.3 ± 33.5	<0.01
ApoA I (mg/dl)	105.8 ± 24.1	114.4 ± 22.8	0.01
ApoB (mg/dl)	115.3 ± 25.3	115.5 ± 26.3	ns
ApoE (mg/dl)	5.5 ± 1.7	6.3 ± 4.3	ns
Lp(a) (mg/dl)	40.2 ± 36.5	30.2 ± 27.8	0.07
UA (mg/dl)	6.5 ± 1.5	6.2 ± 1.5	ns

Age, BMI, TC, TG, HDL-C, LDL-C, ApoA I, ApoB, ApoE, Lp(a) and UA are means ± SD. BMI: body mass index, *smoked more than 20 cigarettes a day for at least five years. TC: total cholesterol, TG: triglyceride, HDL-C: high-density lipoprotein cholesterol, LDL-C: low-density lipoprotein cholesterol, Apo: apoprotein, Lp(a): lipoprotein(a), UA: uric acid, ns: not significant.

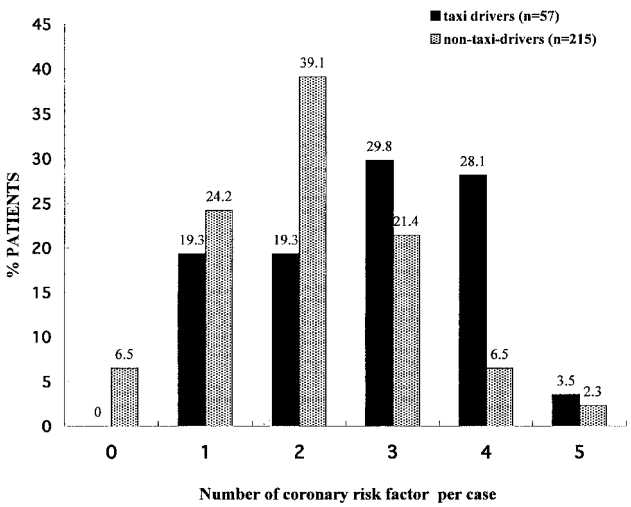

Fig. 1. Comparison of coronary risk factors between taxi drivers and non-taxi-drivers.

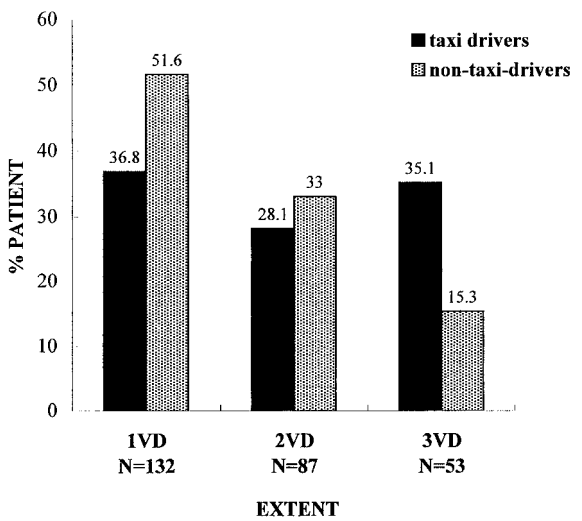

Fig. 2. Number of diseased vessels detected by coronary angiography for taxi drivers and non-taxi-drivers.
1VD=one-vessel disease, 2VD=two-vessel disease, 3VD=three-vessel disease.

statistically significant correlations between multivessel disease (MVD) and the following factors: diabetes mellitus, smoking, ApoAI, divorce, and having more than three coronary risk factors. In non-taxi drivers, there were statistically significant correlations between MVD and the following factors: diabetes mellitus, smoking, TG, ApoB, and having more than three risk factors.

Table 3 shows the results of multivariate logistic regression

Table 2. Comparison of single and multiple vessel disease for taxi drivers and non-taxi-drivers

	taxi drivers			non-taxi-drivers		
	SVD N=21	MVD N=36	p-value	SVD N=111	MVD N=104	p-value
Age (year)	53.6 ± 4.5	54.4 ± 4.3	ns	54.6 ± 4.4	53.7 ± 4.4	ns
BMI (kg/m^2)	24.5 ± 3.9	26.0 ± 3.3	ns	24.2 ± 2.9	24.7 ± 3.0	ns
Diabetes mellitus (%)	19.0	69.4	< 0.001	18.9	36.5	< 0.01
Hypertension (%)	57.1	58.3	ns	47.7	58.7	0.11
Smoking (%)	81.0	100.0	< 0.01	62.2	78.8	< 0.01
Unmarried (%)	19.0	38.9	ns	12.7	12.5	ns
Divorce (%)	9.5	36.1	< 0.05	4.5	7.7	ns
Having more than 3 risk factors (%)	42.9	72.2	< 0.05	22.5	38.5	< 0.05
TC (mg/dl)	211.1 ± 45.8	222.3 ± 52.6	ns	200.8 ± 36.0	208.4 ± 38.6	ns
TG (mg/dl)	156.2 ± 47.8	191.2 ± 89.3	0.059	152.0 ± 70.5	183.0 ± 93.4	< 0.01
HDL-C (mg/dl)	42.3 ± 12.0	37.2 ± 7.8	0.092	42.7 ± 12.0	40.8 ± 12.6	ns
LDL-C (mg/dl)	137.6 ± 44.3	146.8 ± 39.6	ns	127.7 ± 32.7	131.0 ± 34.5	ns
ApoA I (mg/dl)	114.1 ± 27.8	100.8 ± 20.3	< 0.05	114.3 ± 24.7	114.5 ± 20.8	ns
ApoB (mg/dl)	116.8 ± 29.2	114.5 ± 23.1	ns	111.0 ± 24.6	120.4 ± 27.3	< 0.01
ApoE (mg/dl)	5.9 ± 1.7	5.3 ± 1.7	ns	6.3 ± 5.5	6.3 ± 2.3	ns
Lp(a) (mg/dl)	40.8 ± 40.2	39.8 ± 34.5	ns	31.0 ± 30.9	29.5 ± 24.4	ns
UA (mg/dl)	6.4 ± 1.6	6.5 ± 1.4	ns	6.2 ± 1.5	6.3 ± 1.5	ns

SVD: single vessel disease (1VD), MVD: multivessel disease (2VD + 3VD), ns: not significant. Abbreviations as Table 1.

Table 3. Factors related to multivessel disease for taxi drivers and non-taxi-drivers

	taxi drivers			non-taxi-drivers		
variable	OR	(95%CI)	p-value	OR	(95%CI)	p-value
Age (year)	1.280	(0.960-1.710)	0.09	0.975	(0.901-1.056)	ns
BMI (kg/m^2)	1.412	(1.001-1.992)	<0.05	0.946	(0.833-1.075)	ns
Diabetes mellitus*	106.64	(3.137-3624.388)	< 0.01	3.590	(1.617-7.969)	< 0.05
Hypertension**	0.041	(0.020-0.805)	< 0.05	2.443	(1.196-4.990)	< 0.05
Smoking†	–	–	–	3.069	(1.448-6.503)	< 0.01
Divorce††	2.048	(0.166-25.306)	ns	2.080	(0.402-10.760)	ns
TC (mg/dl)	1.024	(0.990-1.060)	ns	0.988	(0.972-1.005)	ns
TG (mg/dl)	1.001	(0.977-1.025)	ns	1.006	(1.001-1.012)	< 0.05
Lp(a) (mg/dl)	1.004	(0.974-1.035)	ns	1.000	(0.988-1.012)	ns
ApoAI (mg/dl)	0.952	(0.901-1.007)	0.09	1.014	(0.997-1.032)	ns
ApoB (mg/dl)	0.990	(0.928-1.057)	ns	1.028	(1.001-1.056)	< 0.05
ApoE (mg/dl)	0.545	(0.200-1.489)	ns	0.947	(0.837-1.072)	ns
Lp(a) (mg/dl)	1.004	(0.974-1.035)	ns	1.000	(0.988-1.012)	ns
UA (mg/dl)	2.584	(0.926-7.210)	0.07	1.071	(0.846-1.357)	ns

OR: odds ratio, CI: confidence interval. Abbreviations as in Table 1, ns: not significant. *0=Non Diabetes mellitus, 1=Diabetes mellitus; **0=Non Hypertension, 1=Hypertension; †0=Non Smoking, 1=Smoking; ††0=Non Divorce, 1=Divorce; For other variables the actual numbers were used.

analysis for both taxi drivers and non-taxi-drivers (MVD was treated as a dependent variable). The following 12 factors were selected as independent variables in the two groups: age, BMI, divorce, diabetes mellitus, hypertension, UA, TC, TG, Lp(a), ApoAI, ApoB, and ApoE. For non-taxi-drivers, smoking was also treated as an independent factor. Therefore, 13 factors were used for analysis for non-taxi-drivers. Since 100% of taxi-driver patients with MVD were smokers, smoking was not treated as an independent factor. Accordingly, the above 12 factors were used for multivariate

logistic regression analysis for taxi drivers.

For taxi drivers, there were statistically significant correlations between MVD and the following factors: BMI, diabetes mellitus and hypertension. For non-taxi-drivers, there were statistically significant correlations between MVD and the following factors: diabetes mellitus, smoking, hypertension, TG, and ApoB.

Discussion

In 1953, Morris reported that the prevalence of ischemic heart disease (IHD) was high among bus drivers in England[1]. Since then, the relationship between occupational driving and IHD has been examined closely. In Japan, there have been many reports on coronary heart disease among taxi drivers. These studies can be classified into three types: 1) comparisons of risk factors and ECG between taxi drivers and non-taxi-drivers[14], 2) surveys on stress and eating habits among taxi drivers[15], and 3) studies of effects of taxi-driving on the circulation kinetics among taxi drivers[19]. Almost all these studies indicated that taxi drivers were at high risk for coronary artery disease.

The present study investigated IHD patients who were taxi drivers, using CAG to clarify the characteristics of coronary artery lesions in taxi drivers with coronary heart disease.

Coronary risk factors

In this study, when compared to non-taxi-driver patients, the levels of BMI and serum LDL-C and the prevalence of diabetes mellitus and smoking were significantly higher and the level of ApoAI was lower for taxi-driver patients. Previous comparative studies on coronary risk factors have also shown a high prevalence of obesity[15], heavy smoking (more than 40 cigarettes a day)[16], and diabetes mellitus, and high levels of total serum cholesterol[17, 18] in taxi drivers.

The coronary risk factors associated with the taxi-driver patients were similar to those reported in previous studies, suggesting that the working environment particular to taxi drivers may play a role in the development of risk factors and coronary artery disease. Hattori characterized the working environment of taxi drivers as follows[14]: 1) continuous tension caused by driving, 2) lack of exercise, 3) exposure to various harmful environments, 4) changes in living and eating habits caused by irregular work schedule and working a graveyard shift, and 5) pressure to fill quotas. These factors, especially irregular eating habits and lack of exercise, can cause obesity and diabetes mellitus. They may also affect the lipid metabolism. When compared to non-taxi-driver patients, the level of LDL-C was higher and that of ApoAI was lower for taxi-driver patients. Diet habits and physical activity are important determinants for the level of LDL-C, which plays an important role in the progression of coronary heart disease[31]. ApoAI is a main structural apoprotein of HDL-C, a powerful antiatherosclerogenic lipoprotein[32]. It has been reported that decreases in ApoAI facilitate the progression of coronary heart disease[33].

High prevalence of smoking among taxi drivers may also contribute to the development of coronary artery disease. It was speculated that stress induced by traffic jams or looking for customers causes taxi drivers to smoke more cigarettes[34, 35].

The taxi-driver patients not only had a high prevalence of each risk factor, but also tended to have three or more risk factors simultaneously. As reported in the Framingham study, coronary risk factors synergistically contribute to the onset and exacerbation of coronary disease[36].

Social factors and coronary heart disease

According to the 1990 report on population dynamics in various businesses and industries[12], the divorce rate was highest for workers in the service industry, followed by the transportation and communication industry. This study showed that the prevalence of unmarried and divorced men was higher for taxi-driver patients than for non-taxi-driver patients. Among taxi drivers, MVD patients had a higher prevalence of divorce than SVD patients, which suggests that the marital status of taxi drivers may contribute to the development of coronary heart disease. As far as the relationship between IHD and marital status is concerned, it has been reported that, for both men and women, being unmarried and having a history of divorce are risk factors for cardiovascular disease[37]. Medalie found that the higher the level of affection received from a spouse, the lower the risk for stenocardia[38]. Seeman performed CAG, and investigated the relationship between coronary atherosclerosis and social support[39]. The results showed that coronary atherosclerosis was inversely correlated with emotional support, such as "being loved," more significantly than with structural support. The cause of a high prevalence of divorce among taxi drivers is not clear: Do people become taxi drivers after divorce? Are taxi drivers in general more likely to divorce? Does the working environment of taxi drivers cause divorce? In any case, it is easy to see that divorce brings about changes in people's eating habits and lifestyle. In addition, although stress and life events were

not analyzed in the present study, the effect of emotional stress caused by divorce on the risk of coronary heart disease cannot be ignored[40].

Characteristics of coronary lesions in taxi drivers

When compared to non-taxi-driver patients, the prevalence of having multivessel coronary artery disease was higher for taxi-driver patients. Nishiyama and colleagues investigated the natural history in 990 patients with coronary heart disease (>75% luminal narrowing), and compared survival rates in relation to the number of diseased vessels[41–43]. The long-term prognosis for patients with one-vessel disease was relatively favorable, but it was poor for those with three-vessel disease, regardless of the presence of myocardial infarction. The higher prevalence of three-vessel disease in taxi-driver patients suggested that taxi drivers are at a greater risk of death from IHD than non-taxi-drivers.

Factors related to multiple diseased vessels

CAG and autopsy studies have shown that more than one coronary artery is affected in diabetic patients[44–47]. When factors related to the presence of multiple diseased vessels were analyzed, the presence of diabetes mellitus was found to be significantly related to multivessel disease in both groups. Since the odds ratio of diabetes mellitus was higher for taxi-driver patients than for non-taxi-driver patients, the presence of diabetes mellitus is a particularly important indicator of risk among taxi-driver patients.

Limitations of the present study

The study population was a certain limited group of patients with IHD in whom clear signs of severe luminal narrowing were detected by CAG. Therefore, the results of this study are not necessarily applicable to all taxi drivers, since there may be bias in selecting patients.

Secondly, most subjects in the present study were outpatients who were residents of Tokyo or the metropolitan Tokyo area, so they constituted a typical city-patient population. Depending on whether the area of residence is a city or rural area, patients eating habits, living activities and stress exposure vary, and these factors are believed to affect the progression of coronary heart disease[48, 49]. One Danish study showed that the risk of cardiovascular disease was higher for drivers in high-traffic areas than for those in less congested areas[50, 51], thus proving that living environment affects the progression of coronary heart disease.

Another issue is the distinction between taxi drivers employed by private companies and self-employed taxi drivers. Of the 57 taxi driver patients in this study, 54 were employed by private taxi companies and 3 were self-employed. Between 1970 and 1980, the mortality rate from IHD was higher for male taxi drivers employed by private companies than for workers in any other occupation in Denmark, but the mortality rate was 10% lower for self-employed taxi drivers[52].

In order to further investigate these issues, it will be necessary to conduct prospective studies to compare: taxi drivers with and without severe luminal narrowing detected by CAG; taxi drivers in cities and rural areas; and self-employed taxi drivers and taxi drivers employed by private companies.

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