

Chapter 18. Atherosclerosis and myocardial disease in relation to physical activity of occupation

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This study supports the data of other authors in finding that the proportional mortality of sudden heart death and coronary heart disease is greater in men aged 40–59 years with sedentary occupations than in those with strenuous occupations. Clear evidence was found of an association between the extent of raised coronary lesions (mainly fibrous plaque and calcified lesions in the left anterior descending coronary artery and complicated lesions in each artery) and inactivity of occupation. The evidence for a similar association with the prevalence of coronary stenosis, myocardial lesions, and the extent of raised lesions of the aorta was suggestive but less clear. There was no evidence of an association between the physical activity of occupation and the extent of calcified lesions in the aorta or coronary arteries. Prevalence and extent of atherosclerotic and myocardial lesions were compared in each of 6 cause of death groups, between those who had been in strenuous, medium, and sedentary occupations.

This chapter describes an attempt to establish whether there are relationships between the physical activity of work and the extent of atherosclerosis in the coronary arteries or aorta, or the prevalence of lesions in these arteries or the myocardium.

METHOD

Information on the physical activity of work was obtained on about 2600 men aged 40–59 years from the five towns. Women were not included, as in many cases the occupation given was “housewife”. There were relatively few deaths in men below the age of 40, and in many instances the occupation given for men of 60 and above was “pensioner” or “retired”.

The numbers for the two age groups 40–49 and 50–59 in three degrees of physical activity of work, and by town, are shown in Table 64; 94% of all deaths in the age/sex group were included.

The physical activity of the work of each subject was classified on the basis of the stated occupation in one of three categories—sedentary, medium, or strenuous. This classification was carried out for each town by a native of the country concerned without reference to the clinical or pathological findings. The persons selected for this task had a

Table 64. Number of deaths (all causes), by age, physical activity of work, and town (males)

Town	Age group	Physical activity of work		
		Sedentary	Medium	Strenuous
Malmö	40–49	137	69	19
	50–59	295	188	70
	all	432	257	89
Prague	40–49	30	10	6
	50–59	136	65	33
	all	166	75	39
Ryazan	40–49	48	77	72
	50–59	83	96	119
	all	131	173	191
Yalta	40–49	32	65	32
	50–59	57	108	41
	all	89	173	73
Tallin	40–49	57	144	59
	50–59	109	222	137
	all	166	366	196
All towns	40–49	304	365	188
	50–59	680	679	400
	all	984	1044	588

good knowledge of the terms used to describe occupations and of the conditions of work in the towns concerned.

SOURCES OF ERROR

One possible source of error was that the occupational description was insufficient to indicate the real physical activity of work; for instance, a "construction worker" might be classified as having a strenuous occupation although, in fact, his job might be administrative or done by machines and was therefore really sedentary, and, for example, there was no means of knowing whether a particular clerk was especially active, e.g., spending most of his time taking papers and ledgers from one office to another. However, it is probable that subjects employed in what was classified as sedentary work indulged in less physical activity at work, on average, than those whose work was classified as strenuous.

Another possible source of error was that the classification was often based on the occupational description given at the time of the subject's last illness. Some subjects, for instance, those who had been ill for a long time, may have changed from strenuous to sedentary work because of their illness but before their terminal illness. This could bias the findings. However, it should be possible to assess this effect indirectly by comparing the proportion of deaths due to long-acting conditions unlikely to be associated with physical activity of work in subjects who were said to be in sedentary and strenuous occupations during life.

Cancer deaths provide a suitable test group. We should expect many cancer patients to have changed their occupation to a sedentary one before the terminal illness. Cancer is not associated with physical activity of work particularly. Thus, if pre-terminal change of occupation did not occur, we should expect the death rates from cancer to be the same in the strenuous and sedentary subjects. If it did occur, we should expect death rates to be lower in the strenuous occupation. Table 65 shows that proportional mortality from cancer was lower for strenuous occupations. The difference was rather slight but significant for all towns together (ratio of sedentary to strenuous = 1.2).

We should expect the change of occupation prior to terminal illness to be least in subjects dying by accident or suicide, or suddenly. Further, there is no reason to expect that suicide is associated with physical activity of occupation, but accidents are

Table 65. Proportional mortality (%) of cancer, suicide, accident, and sudden heart deaths, according to physical activity of work (males aged 40-59)

Disease	Age group	Physical activity of work		
		Sedentary	Medium	Strenuous
Cancer (all towns)	40-49	20	17	10
	50-59	26	27	24
	40-59	24	24	20
Suicide (Malmö only)	40-49	12	19	16
	50-59	8	5	7
	40-59	9	9	9
Accidental deaths (all towns)	40-49	23	38	43
	50-59	9	12	21
	40-59	13	21	28
Sudden deaths (all towns)	40-49	26	19	20
	50-59	30	26	24
	40-59	29	24	22

known to be more common in strenuous workers, and sudden heart deaths in sedentary workers. Table 65 shows that this expectation was borne out. The proportion of deaths due to suicide was the same in the sedentary and the strenuous workers in Malmö (there were insufficient data from other towns). In all towns^a, accidental deaths were more frequent in those who had strenuous work (Table 65—ratio of strenuous to sedentary = 2.7).

Thus there is some support for the idea that in death following prolonged illness (e.g., cancer) there may be a bias towards underestimating strenuous activity. It would be less than 20% for cancer deaths, and therefore for all deaths is likely to be a good deal smaller.

RESULTS

Examination of data from the different towns showed that while there was variation, often associated with the small numbers involved, the general direction was the same for all. The data have therefore been pooled.

Aorta

Table 66 shows the mean value for the extent of different atherosclerotic lesions of the thoracic and abdominal aorta, according to the physical activity of work (all towns considered together).^a At age 50-59, there was less atherosclerosis (total amount,

^a The trend was the same for each town separately, but this is not shown in the Table.

Table 66. Extent of atherosclerotic lesions (% of surface) in aorta, according to physical activity of work (males aged 40–59)

Lesions	Age group	Thoracic aorta			Abdominal aorta			Average aorta		
		Physical activity of work			Physical activity of work			Physical activity of work		
		Sedentary	Medium	Strenuous	Sedentary	Medium	Strenuous	Sedentary	Medium	Strenuous
Total amount of atherosclerosis	40–49	25	22	23	42	38 ^a	38 ^a	34	30 ^a	30
	50–59	37	34 ^a	31 ^c	59	53 ^c	50 ^c	48	44 ^b	41 ^c
Fatty streak	40–49	12	12	12	11	13 ^a	13	11	13	13
	50–59	8	8	7	6	6	7	7	7	7
Fibrous plaque	40–49	13	10 ^a	10	29	23 ^b	23 ^a	21	16 ^b	17 ^a
	50–59	28	25 ^a	23 ^b	44	41 ^b	38 ^c	36	33 ^b	31 ^c
Complicated lesions	40–49	0.3	0.1	0.1 ^a	1.9	0.7 ^a	1.1	1.1	0.4 ^a	0.6
	50–59	1.1	1.1	0.6 ^b	5.8	4.1 ^b	2.6 ^c	3.5	2.6 ^a	1.6 ^c
Calcified lesions	40–49	0.1	0.1	0.0	0.9	0.8	0.9	0.5	0.5	0.5
	50–59	0.4	0.5	0.4	2.9	2.7	2.6	1.7	1.6	1.5
Raised lesions	40–49	13	10 ^a	10	31	25 ^b	25 ^a	22	17 ^b	18 ^a
	50–59	29	27	24 ^c	53	47 ^c	44 ^c	41	37 ^b	34 ^c

^a Less than sedentary, $0.01 < P < 0.05$.

^b Less than sedentary, $0.001 < P < 0.01$.

^c Less than sedentary, $P < 0.001$.

fibrous plaque, complicated lesions, and raised lesions) in both parts of the aorta in the strenuous than in the sedentary workers. There was a similar trend at age 40–49 but it did not always reach levels of significance. The difference was more marked for the abdominal than for the thoracic aorta. There was no trend with physical activity of occupation for fatty streak or calcified lesions.

Coronary arteries

Table 67 shows mean values for the extent of atherosclerosis in the coronary arteries. At ages 40–49 and 50–59 the strenuous workers had significantly less extensive atherosclerosis of all types, except calcification, than the sedentary workers. The calcified lesions in the left anterior descending coronary artery were less extensive in the strenuous than in the sedentary workers at age 50–59. However, calcified lesions in the left circumflex and right coronary arteries did not differ significantly in extent between physical activity groups.

Coronary stenosis, coronary thrombosis, and myocardial lesions

Table 68 shows that for age 50–59 coronary stenosis was less frequent in the strenuous workers than in the sedentary workers, and in both age groups coronary thrombosis, fresh myocardial

infarction, and large myocardial scar were less frequent in the strenuous workers. The characteristic trend is well shown for all conditions at age 50–59 and for coronary stenosis and thrombosis at age 40–49.

DISCUSSION

The data quoted so far indicate an association of atherosclerotic and myocardial lesions with sedentary work, and an inverse association with strenuous work. The problem is whether these associations are direct or indirect. For example, indirect association might occur if diseases that are associated with atherosclerosis are more common in sedentary workers than in strenuous workers. In this case, atherosclerosis would be regarded as being associated with the disease and the disease with the degree of activity of work. That this might be so can be seen from Table 69, which shows the proportion of all deaths in which hypertension, diabetes mellitus, or coronary heart disease were recorded, according to physical activity of work. All three conditions were commoner in sedentary workers than in strenuous workers and all are associated with atherosclerosis. Also (Table 65), accidental deaths, which were associated with little atherosclerosis, were more common in strenuous workers than in

Table 67. Extent of atherosclerotic lesions (% of surface) in the coronary arteries, according to physical activity of work (males aged 40-59)

Lesions	Age group	Right coronary artery			Left anterior descending coronary artery			Left circumflex coronary artery			Average coronary artery		
		Physical activity of work			Physical activity of work			Physical activity of work			Physical activity of work		
		Sedentary	Medium	Strenuous	Sedentary	Medium	Strenuous	Sedentary	Medium	Strenuous	Sedentary	Medium	Strenuous
Total amount of atherosclerosis	40-49	38	28 ^c	27 ^c	33 ^a	30 ^b	30 ^b	29	21 ^c	23 ^a	34	27 ^c	26 ^c
	50-59	52	44 ^c	43 ^c	42 ^c	42 ^c	42 ^c	43	37 ^c	35 ^c	48	41 ^c	40
Fatty streak	40-49	5	4	5	3	3	3	4	3	3	4	4	4
	50-59	3	3	4	2	3	3	3	3	3	3	3	3
Fibrous plaque	40-49	32	23 ^c	22 ^c	28 ^a	25 ^b	25 ^b	25	18 ^c	19 ^a	30	23 ^c	22 ^c
	50-59	45	39 ^c	36 ^c	36 ^c	36 ^c	36 ^c	37	32 ^c	30 ^c	41	35 ^c	34 ^c
Complicated lesions	40-49	0.4	0.2 ^b	0.2 ^b	0.6	0.1 ^c	0.1 ^c	0.1	0.0	0.1	0.4	0.3	0.1 ^c
	50-59	1.1	0.5 ^c	0.6 ^a	0.5 ^b	0.3 ^c	0.3 ^c	0.6	0.3 ^a	0.1 ^b	1.0	0.4 ^c	0.3 ^c
Calcified lesions	40-49	0.4	0.5	0.5	1.0	1.6	1.6	0.2	0.4	0.5	0.5	0.6	0.8
	50-59	2.3	1.8	1.8	3.9	3.2	3.2	2.6	2.5	1.8	3.2	2.7	2.3 ^a
Raised lesions	40-49	33	24 ^c	23 ^c	30 ^a	27 ^b	27 ^b	25	18 ^c	19 ^a	30	23 ^c	22 ^c
	50-59	48	41 ^c	39 ^c	40 ^c	40 ^c	40 ^c	40	34 ^c	32 ^c	46	38 ^c	36 ^c

^a Less than sedentary, 0.01 < P < 0.05.

^b Less than sedentary, 0.001 < P < 0.01.

^c Less than sedentary, P < 0.001.

Table 68. Prevalence (%) of lesions in coronary arteries and myocardium according to physical activity of work (males aged 40-59 years, all deaths)

Lesion	Age group	Physical activity of work		
		Sedentary	Medium	Strenuous
Stenosis in any coronary artery	40-49	13	9	7
	50-59	30	24 ^a	20 ^b
Coronary thrombosis	40-49	8	4	1.6 ^b
	50-59	12	6 ^c	4 ^c
Fresh myocardial infarction	40-49	15	8 ^a	7
	50-59	19	12 ^c	8 ^c
Large myocardial scar	40-49	14	9 ^a	9
	50-59	30	18 ^c	16 ^c

^a Less than sedentary, P < 0.05.

^b Less than sedentary, P < 0.01.

^c Less than sedentary, P < 0.001.

Table 69. Proportional mortality (%) of deaths in which hypertension, diabetes mellitus, or coronary heart disease were recorded, according to physical activity of work (all towns, men aged 40-59)

Disease recorded	Age	Physical activity of work		
		Sedentary	Medium	Strenuous
Hypertension	40-49	16	15	12
	50-59	23	25	18
	40-59	20	21	16 ^a
Diabetes mellitus	40-49	2	1	0.5
	50-59	6	3 ^b	2 ^b
	40-59	5	2 ^c	1.4 ^c
Coronary heart disease	40-49	17	12	12
	50-59	27	18	15
	40-59	24	16	14

^a Less than sedentary, 0.01 < P < 0.05.

^b Less than sedentary, 0.001 < P < 0.01.

^c Less than sedentary, P < 0.001.

Table 70. Number of deaths due to accident (all towns)

Age group	Physical activity of work		
	Sedentary	Medium	Strenuous
40-49	70	140	80
50-59	59	82	83
40-59	129	222	163

Table 71. Extent of atherosclerotic lesions (% of surface) in aorta, according to physical activity of work (accident deaths only, males aged 40–59)

Lesions	Age group	Thoracic aorta			Abdominal aorta			Average aorta		
		Physical activity of work			Physical activity of work			Physical activity of work		
		Sedentary	Medium	Strenuous	Sedentary	Medium	Strenuous	Sedentary	Medium	Strenuous
Total amount of atherosclerosis	40–49	18	18	20	36	32	34	27	25	27
	50–59	22	23	24	45	40	41	33	31	32
Fatty streak	40–49	11	12	13	16	17	15	14	15	14
	50–59	7	7	8	7	9	9	7	8	8
Fibrous plaque	40–49	7	5	7	19	15	18	13	10	13
	50–59	14	15	15	32	28	29	23	21	22
Complicated lesions	40–49	0.1	0.1	0.0	0.4	0.2	0.2	0.3	0.1	0.1
	50–59	0.5	0.6	0.3	2.1	2.0	1.5	1.3	1.3	0.9
Calcified lesions	40–49	0.0	0.1	0.0	0.5	0.2	0.4	0.3	0.1	0.2
	50–59	0.2	0.3	0.2	3.5	1.7	1.8	1.9	1.0	1.0
Raised lesions	40–49	7	5	7	20	15	19	13	10	13
	50–59	15	16	16	38	31	33	26	24	24

sedentary workers. On the other hand, cancer deaths (Table 65), which were generally associated with less atherosclerosis than other deaths, were a little more common in sedentary workers than in strenuous workers. On the whole, it might very well be that some, if not all, of the difference in atherosclerosis between strenuous and sedentary workers was related to a different proportion of diseases rather than directly to the physical activity of work.

As a check, we looked at groups of deaths from different causes, some associated with much atherosclerosis and others with little. In each group we compared atherosclerotic and myocardial lesions in the sedentary, medium, and strenuous workers. The number of deaths in the age groups 40–49, 50–59, and 40–59 due to accidents in people whose occupation was sedentary, medium, and strenuous is shown in Table 70. The differences between sedentary, medium, and strenuous occupations seen in atherosclerosis of the aorta when all deaths were taken into consideration (Table 66) disappeared when accidental deaths only were considered (Table 71), whereas some of the differences in the coronary arteries remained. This was true with regard to the right coronary artery and the left anterior descending coronary artery (total amount of atherosclerosis, fibrous plaque, and raised lesions). Table 72, on the other hand, shows that the difference seen for all deaths in stenosis in the coronary arteries and large

myocardial scar disappeared when only accidental deaths were examined.

We wished to ascertain whether there were any factors in which the occupational groups differed, such as age and obesity, that might bias the results, and, if so, in which direction. Table 73 shows the mean values and standard errors for age and subcutaneous fat in men aged 40–59 years who died of accident, according to the physical activity of their work; the strenuous workers were evidently no different from the sedentary workers in age, but were, on average, thinner. In Chapter 16 it was shown that the mean amount of atherosclerosis of the aorta differed very little between the fattest and thinnest tercile when hypertensive and diabetic deaths were excluded. The picture was quite different for lesions in the coronary arteries and myocardium;

Table 72. Prevalence (%) of lesions in coronary arteries and myocardium, according to physical activity of work (accident deaths only, males aged 40–59)

Lesion	Age group	Physical activity of work		
		Sedentary	Medium	Strenuous
Stenosis (any coronary artery)	40–49	3	0.7	4
	50–59	9	12	12
Prevalence of large myocardial scar	40–49	1.4	0.7	1.2
	50–59	7	10	6

Table 73. Mean values (and standard errors) for age and thickness of subcutaneous fat, according to physical activity of occupation (accidental deaths only, men aged 40–59, all towns)

	Physical activity of work		
	Sedentary	Medium	Strenuous
Age (years)	49.1 (0.49)	47.8 (0.36)	49.7 (0.48)
Thickness of subcutaneous fat (mm)	18.7 (1.37)	15.1 (0.66)	12.7 ^a (0.64)

^a Significantly less than the mean for the sedentary workers ($P < 0.001$).

here, the fattest tercile had considerably more disease than the thinnest.

Some or all of the differences found in the coronary arteries and myocardium according to physical activity of work in the accidental deaths may have been due to an associated difference in obesity, but if so, it would be necessary to explain why coronary stenosis did not show the same trend. The impression gained from study of the accidental death material was that, apart from the extent of raised lesions of the coronary artery, a great deal of the difference in atherosclerosis and myocardial lesions seen with different degrees of physical activity of occupation was the result of an association with factors other than physical activity.

Another possible explanation was that, since accidental deaths were characterized by a low level of atherosclerosis (equivalent to that in the low atherosclerosis reference group), the effect of physical activity was too small to be shown at this level and perhaps physical activity, although having no effect at this level, had an effect at higher levels. We therefore examined deaths of a relatively specific nature associated with much atherosclerosis (coronary heart disease, coronary heart disease without hypertension/diabetes, sudden heart death), comparing them with each other and with all deaths, all deaths without hypertension/diabetes, and accidental deaths, for the relation of the lesion to the physical activity of work. We calculated the observed/expected ratios on the standardized average atherosclerosis group scales. If physical activity had been associated with a decrease in the lesion, we should have expected the ratios to decline from the sedentary through the medium to the strenuous activity groups.

This was indeed the case for the extent of raised lesions in the average coronary artery in all the disease groups. In each of the six disease groups the ratio was smaller for strenuous than for sedentary workers and in all but one there was a well-marked trend, with the ratio for medium workers occupying an intermediate position. The extent of raised lesions in the coronary artery in sedentary workers could be compared with that in strenuous workers by dividing the score of the former by that of the latter in each disease group. For example, for all deaths the value was 1.11 : 0.88, or 1.3. The value for the other disease groups varied between 1.2 (sudden heart death) and 1.4 (accidental death). It was not reduced by the absence of hypertension and diabetes. We concluded that there was a strong association, independent of the cause of death, between the extent of raised lesions of the coronary arteries and lack of physical activity at work. We suspected on the basis of the data in Table 67 that little of this difference would be related to complicated or calcified lesions and most would be due to fibrous plaque. This was indeed the case. The extent of calcified lesions of the coronary arteries was not associated with physical inactivity of work. In only two groups (all deaths and sudden heart deaths) was the ratio smaller in the strenuous than in the sedentary workers. In the two coronary heart disease groups the reverse was the case. In the accident group the ratios were equal in the sedentary and strenuous workers. None of the disease groups showed a particular trend.

In the case of prevalence of coronary stenosis, fresh myocardial infarction, and large myocardial scar the evidence was in favour of an association with physical inactivity of work, but the association was not so clear as for extent of raised lesions of coronary artery. Thus, for each of the three lesions, and in each disease group other than accidental death, the strenuous workers had a lower ratio than the sedentary workers. However, in accidental deaths the reverse was the case for stenosis, there were no cases with fresh myocardial infarction, and the ratios were equal in large myocardial scar. A trend from highest ratios in sedentary workers to lowest ratios in strenuous workers was rarely seen (all deaths for coronary stenosis, all deaths and sudden heart deaths for fresh myocardial infarction, and no groups for large myocardial scar).

There was no evidence of an association between the physical activity of work and extent of calcified lesions of the aorta. In the case of extent of raised lesions of the aorta the evidence was not clear but

slightly in favour of an association. In all groups except accidental death, the ratio for strenuous workers was less than that for sedentary workers. In accidental deaths there was little difference. In all the other groups a trend was seen. The absence of hypertension and diabetes from all deaths or coronary heart deaths did not alter any of the relationships described above.

Several studies have demonstrated an increased risk of mortality from coronary heart disease in those employed in sedentary occupations compared with those in more active occupations, for example, bus drivers compared with bus conductors in the United Kingdom (4, 5), railroad clerks compared with switchmen and servicemen in the USA (6), and post office clerks compared with postmen delivering the mail in the USA (2). Morris et al. showed a similar relationship with morbidity from coronary heart disease (5) and Frank et al. in a study of males from an insured population of New York City showed an increased risk of death in subjects with sedentary occupations suffering a first attack of myocardial infarction compared with similar subjects in more active occupations at the time of the first attack (1). Our data (Tables 65 and 69) support this suggestion in that proportional mortality from coronary heart disease and sudden heart death was greater in sedentary than in strenuous workers.

Data on atherosclerotic and myocardial lesions in relation to physical activity of work are much more scarce. Morris & Crawford reported a survey of 25 consecutive autopsies carried out in each of 206

hospitals or hospital groups (about 90% of all possible pathology centres in the British National Health Service)—the National Necropsy Survey (3). The autopsy investigations and criteria used were somewhat different from those in the WHO study. Comparison can be made, however, with the prevalence of large myocardial scar (greater than 1.5 cm in the National Necropsy Survey, greater than 0.5 cm in the present study). Further, the National Necropsy Survey "basic" group of men aged 45–59 (deaths from injuries, infections, and cancer) was to some extent comparable with accidental deaths in the present study at age 40–59, in that both were composed of low atherosclerosis deaths.

In the National Necropsy Survey, large myocardial scar was more frequent in the sedentary basic deaths than in the strenuous (a 6-fold difference, 2-fold if small scars were included), whereas in the present study no difference was found. Morris & Crawford found little difference in the prevalence of "much coronary atherosclerosis with or without focal obstruction" in their sedentary and strenuous occupation groups in several disease categories. The WHO study showed a consistent and clear increase in the extent of raised lesions of the coronary arteries in sedentary compared with strenuous workers. Both studies indicated that physical inactivity was associated with coronary lesions of some kind. The emphasis of the present study was on the extent of fibrous plaque and of the other study on coronary occlusion. Differences may well have been due to the methods and criteria used.

RÉSUMÉ

CHAPITRE 18. RAPPORTS ENTRE L'ATHÉROSCLÉROSE ET LA MALADIE MYOCARDIQUE D'UNE PART, L'ACTIVITÉ PHYSIQUE PROFESSIONNELLE DE L'AUTRE

Cette étude recoupe les données d'autres auteurs qui ont observé que la létalité relative des crises subites d'origine cardiaque et de la cardiopathie coronarienne est plus grande chez les hommes âgés de 40-59 ans à profession sédentaire que chez ceux qui ont des métiers exigeant une activité physique intense. Certains faits ont été trouvés qui indiquent une association manifeste entre le degré de lésions coronaires saillantes (essentiellement plaque fibreuse et lésions calcifiées dans l'artère coronaire antérieure gauche descendante et lésions compliquées dans chaque artère) et l'inactivité physique imposée par la profession. D'autres faits sont

évoqueurs, quoique moins nettement, d'une association analogue avec la prévalence de la sténose coronaire, des lésions myocardiques et du degré de lésions saillantes de l'aorte. L'existence de rapports entre l'activité physique professionnelle et l'étendue des lésions calcifiées dans l'aorte et les artères coronaires n'est pas prouvée. La prévalence et l'extension des lésions athéroscléreuses et myocardiques sont comparées dans chacun des six groupes de causes de décès, entre les sujets qui ont exercé un métier comportant une activité physique interse, moyenne, ou une profession sédentaire.

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