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Latent ischemic heart disease in sea captains

by Reidar Mundal, MD,^{1, 2} Jan Erikssen, MD, PhD,² Kaare Rodahl, MD, PhD¹

MUNDAL R, ERIKSEN J, RODAHL K. Latent ischemic heart disease in sea captains. *Scand j work environ health* 8 (1982) 178—184. For 110 apparently healthy Norwegian captains on ocean-going ships a near maximal bicycle exercise test revealed a pathological exercise electrocardiogram for 10.0 %, while the corresponding results for a comparable group of Oslo men and a group of Norwegian sea pilots were 4.6 and 11.8 %, respectively. The significant difference in prevalence between the captains and Oslo men could not be explained by differences in serum lipids, blood pressure, or a family history of coronary heart disease. The captains were taller and more physically fit than the Oslo men, but they were significantly heavier and had a more rapid age decline in physical performance capacity and a higher prevalence of heavy smokers. Ten of the 11 captains with a pathological exercise electrocardiogram were, or had been, heavy smokers (≥ 20 cigarettes/d). A high caloric intake in relation to caloric expenditure, heavy smoking, and poorly defined factors such as stress, irregular work-hours, and varying climatic conditions are factors to be considered as explanations for these findings. The claim by captains that they have a higher risk than average for developing coronary heart disease was to some extent corroborated in the present study.

Key terms: coronary risk factors, exercise electrocardiography, occupational stress, physical performance capacity.

In 1976 the Norwegian Technical Research Council sponsored a multifaceted research project (the 3-S project) in order to elucidate various aspects of safety at sea. The present study, a subproject of the major investigation, deals with aspects of coronary heart disease (CHD) among captains on ocean-going ships. The rationale for the study was: (i) Norwegian mortality statistics indicate a 15 % excess in age-specific deaths from CHD among "sea officers" (1); (ii) recent data indicate a higher prevalence of latent CHD among Norwegian sea pilots working in the Oslo fjord region than among men of similar age from the same geographic area (6); and (iii) the Norwegian Shipmasters' Association has repeatedly put forward the unproved claim that CHD morbidity is higher among sea officers than among subjects working ashore.

The specific aims of the present study were: (i) to study the prevalence of ischemic response in electrocardiograms (ECGs) to a near maximal bicycle ergometer exercise test among apparently healthy captains aged 40—59 a, in particular among captains free from known or suspected CHD; (ii) to study a number of CHD risk factors among captains; and (iii) to compare the findings in captains with recently reported data from a group of apparently healthy sea pilots and Oslo men of similar age (6, 7, 8, 9).

With this approach it might be possible to determine whether captains have findings suggestive of higher prevalence — and risk — of developing CHD than men of similar age working ashore, and also to ascertain whether the grouping of sea pilots and sea captains occurring in official health statistics is warranted.

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Subjects and methods

Immediately prior to embarkation, 110 apparently healthy Norwegian sea captains aged 40—59 a (68 = 40—49 a, 42 =

50—59 a) participated in the study. The examination replaced the compulsory health examination that takes place before embarkation. According to official statistics a total of 240 captains, regardless of age, had their certificate renewal and compulsory health control in Norway in 1977, as well as in 1978. The exact figure for the period of our investigation (September 1979—September 1980) was not available. During this period 120 captains from the merchant fleet had their health check in Oslo. In our examination three were excluded because of known heart disease and two because of hypertension, whereas five did not want to participate. Thus 110 (92 %) of the 120 men who had their health check in Oslo participated in the study.

The population of Oslo men used for comparative purposes comprised 2,014 men, of whom 992 were 40—49 a of age and 1,022 were 50—59 a of age. Of the 68 sea pilots 37 were 40—49 a of age, and 31 were 50—59 a of age.

For the captains we used exclusion criteria identical to those used for the sea pilots and Oslo men, ie, all men with known or suspected heart disease, hypertension under treatment with drugs, diabetes mellitus, malignancy, and various other diseases were excluded (3, 8). According to these criteria all participants could be classified as apparently healthy.

Identical examination procedures were used in the investigations of the captains, sea pilots, and Oslo men. All of the subjects fasted and refrained from smoking for at least 12 h prior to the test program, which took place, with standardized techniques (8, 13), early in the morning. The test program was as follows: case history evaluation, clinical examination, height/weight measurements, radiography of the heart and lungs, spirometry, vitalographic examination and measurement of peak expiratory flow (Wright's peak flowmeter), blood sampling for testing (including lipid profile), resting ECG, and near maximal bicycle ergometer exercise-ECG testing.

The criteria used for a positive exercise ECG were as follows: (i) ST depression ≥ 1.5 mm for chest-head leads 2—7 or ≥ 1.0 mm ST depression for standard leads 1, 2, aVF, aVL of V_{2-7} , lasting 0.08 s

from the J point in a horizontal or downward sloping direction; and (ii) ST depression for standard leads 1, 2, aVF, aVL or V_{2-7} , lasting 0.08 s from the J point regardless of the slope of the ST segment. All the exercise ECGs of all the groups were read by the same person (JE).

A search for possible differences and contrasts among the three study groups was carried out by means of multiple t-tests, using computerized programs as reported elsewhere (4).

Results

Case history

No difference was found in the family prevalence of CHD of the three groups, nor in the prevalence of dyspepsia or duodenal or ventricular ulcers. Nineteen captains (17.3 %) had never smoked. The corresponding values for the Oslo men and sea pilots were 24.7 and 11.2 %, respectively ($p < 0.01$ for the captains and sea pilots vs the Oslo men). Forty-five percent of the captains, 42 % of the sea pilots, and 46 % of the Oslo men were regularly smoking cigarettes at the time of the examination ($p > 0.05$). However, 18.2 % of the captains smoked ≥ 20 cigarettes/d in contrast to 10.1 % of the sea pilots and 5.5 % of the Oslo men ($p < 0.001$ for the difference between the sea captains and Oslo men).

Clinical findings

Mostly only small differences were noted for the clinical findings of the three groups (tables 1 & 2). However the captains were taller on the average and significantly heavier, particularly captains older than 50 a. The captains also had a marginally lower blood pressure than the Oslo men, whereas the sea pilots had a significantly higher blood pressure than the comparable groups.

Laboratory data

No differences in hemoglobin, erythrocyte sedimentation rate (Westergren), renal function, liver function, or electrolytes were noted (data not shown). Serum cholesterol was almost identical for all the groups, whereas serum triglycerides

Table 1. Comparison of various physiological and biochemical parameters for the captains, sea pilots and Oslo men of similar age.

Parameter	Captains				Sea pilots ^a				Oslo men			
	40—49 a		50—59 a		40—49 a		50—59 a		40—49 a		50—59 a	
	(N = 68)		(N = 42)		(N = 37)		(N = 31)		(N = 992)		(N = 1,022)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Height (cm)	179.1	5.6	178.0	5.6	177.7	4.4	176.0	4.6	177.8	6.6	175.9	6.1
Weight (kg)	81.9	11.1	85.5	11.3	81.5	11.2	80.2	10.3	77.1	10.4	76.2	10.8
Peak expiratory flow (l/min)	589	85	554	61	ND		ND		545	81	500	89
Forced expiratory volume in 1 s (ml)	3,637	714	3,184	571	4,208	596	3,540	902	3,670	756	3,220	735
Vital capacity (ml)	4,774	938	4,259	681	5,030	693	4,451	896	4,683	850	4,240	799
Resting systolic blood pressure (mm Hg) ^b	123	11	129	16	131	13	143	15	129	18	135	17
Resting diastolic blood pressure (mm Hg)	80	9	83	10	92	11	98	10	88	10	90	11
Heart volume (ml/m ² body surface area)	376	50	403	52	390	50	423	62	396	59	408	65
Cholesterol (mmol/l)	6.58	1.27	6.87	1.30	6.58	0.88	6.82	1.18	6.52	1.23	6.75	1.27
Triglycerides (mmol/l)	1.53	1.04	1.45	0.72	1.20	0.71	1.26	0.66	1.32	0.82	1.32	0.70

^a ND = Not done.

^b 1 mm Hg = 133.322 Pa.

Table 2. Level of statistical significance for comparisons of the physiological and biochemical data collected from the three groups studied (data from table 1). (A = captains aged 40—49 a vs sea pilots aged 40—49 a, B = captains aged 40—49 a vs Oslo men aged 40—49 a, C = sea pilots aged 40—49 a vs Oslo men aged 40—49 a, D = captains aged 50—59 a vs sea pilots aged 50—59 a, E = captains aged 50—59 a vs Oslo men aged 50—59 a, F = sea pilots aged 50—59 a vs Oslo men aged 50—59 a, — = not done or data incomparable)

Parameter	Comparison					
	A	B	C	D	E	F
Height	NS	NS	NS	NS	**	NS
Weight	NS	***	*	*	***	*
Peak expiratory flow	—	***	—	—	***	—
Forced expiratory volume	***	—	—	*	—	—
Vital capacity	NS	—	—	NS	—	—
Resting systolic blood pressure	***	*	NS	***	NS	*
Resting diastolic blood pressure	***	*	*	***	**	***
Heart volume	NS	**	NS	***	NS	*
Cholesterol	NS	NS	NS	NS	NS	NS
Triglycerides	NS	*	NS	NS	NS	NS

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, NS = not significant.

were marginally higher among the captains than among the Oslo men (tables 1 & 2).

Exercise test data

There was no difference in the maximal heart rate or maximal blood pressure obtained during the exercise tests of the three groups (tables 3 & 4), and hence the product of the heart rate times the blood pressure was virtually identical for the comparable groups. On the other hand, the captains had a significantly higher work performance capacity than the other

two groups, whereas no significant difference was found between the sea pilots and the Oslo men. Several of the noted differences reached a very high level of significance. As expected, there was a decline in physical performance capacity with age. This decline was more pronounced for the captains than for the Oslo men ($p < 0.001$), even though the captains were superior to the Oslo men at all ages.

Exercise elecardiographic findings

Of the captains 11 (10.0%) had pathological exercise ECGs, the corresponding

Table 3. Exercise test parameters recorded for the captains, sea pilots and Oslo men of similar age during near maximal bicycle exercise.

Parameter	Captains				Sea pilots				Oslo men			
	40—49 a		50—59 a		40—49 a		50—59 a		40—49 a		50—59 a	
	(N = 68)		(N = 42)		(N = 37)		(N = 31)		(N = 992)		(N = 1,022)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Maximal heart rate during exercise test (beats/min)	171	13	159	15	170	12	155	15	168	13	159	13
Maximal blood pressure during exercise test (mm Hg) ^a	208	23	219	30	209	22	213	20	213	22	218	24
Maximal load tolerated for one minute (W)	207	33	181	31	180	34	157	26	187	29	167	33
Total work performed during the exercise test (KJ)	146	53	107	31	111	42	85	49	125	49	97	40

^a 1 mm Hg = 133.322 Pa.

Table 4. Level of statistical significance for comparisons of exercise test data from the three groups studied (data from table 3). (A = captains aged 40—49 a vs sea pilots aged 40—49 a, B = captains aged 40—49 a vs Oslo men aged 40—49 a, C = sea pilots aged 40—49 a vs Oslo men aged 40—49 a, D = captains aged 50—59 a vs sea pilots 50—59 a, E = captains aged 50—59 a vs Oslo men aged 50—59 a, F = sea pilots aged 50—59 a vs Oslo men aged 50—59 a, — = not done or data incomparable)

Parameter	Comparison					
	A	B	C	D	E	F
Maximal heart rate	NS	NS	NS	NS	NS	NS
Maximal blood pressure	NS	NS	NS	NS	NS	NS
Maximal load tolerated for 1 min	***	***	NS	***	***	NS
Total work performed	***	***	NS	***	***	NS

*** $p < 0.001$, NS = not significant.

value of the sea pilots was 8 (11.8 %), and that of the Oslo men 93 (4.6 %) ($p = 0.06$ for the captains vs the Oslo men). If we group the data from the sea pilots and captains, the difference between this aggregated prevalence and the prevalence of the Oslo men becomes highly significant ($p < 0.001$). This difference in prevalence of pathological exercise ECGs cannot be explained by differences in cardiac strain, as shown by the preceding results. Besides, as already mentioned, all the tests were performed or supervised by one of us.

Captains with pathological exercise ECGs had significantly higher serum cholesterol and triglycerides than captains with normal exercise ECGs. Ten of the 11 with a pathological exercise ECG were, or had been, heavy smokers (≥ 20 cigarettes/d). They also had somewhat higher body weight and lower physical performance capacity (data not shown). The same lipid-smoking pattern was reported earlier for the sea pilots and Oslo men with pathological exercise ECGs (4, 6).

Discussion

The so-called 3-S project was launched in 1976 in an attempt to define the size of — and underlying causes for — the very high morbidity and mortality of Norwegian sailors. A recent report summarizes the different aspects involved and gives various recommendations for correcting the work conditions in a broad sense (10). One major finding of the scrutinization of official occupational mortality statistics was the very high death rate from acute, unexpected death among deck officers, and this finding was the main reason for the start of our study (1). It should be noted that “officers” include captains, sea pilots, other deck officers, and engineers. It may be questioned whether this grouping is scientifically sound, since at least the work conditions for engineers and deck officers differ in many respects from that of the captains and sea pilots. On the other hand, sea pilots and captains have similar work conditions in many respects, as well as a similar educational background. A grouping of sea pilots and captains therefore may be warranted, whereas the inclusion of other deck

officers and engineers may dilute findings which prove peculiar to captains and sea pilots.

The claim that captains have a high occupational risk for CHD has been, to some extent, corroborated by our findings, in that a significantly higher prevalence of pathological exercise ECGs was noted for the captains. As already mentioned, the identical test techniques indicate that this is a true finding. If we group the sea pilots and captains together, the difference in prevalence of pathological exercise ECGs between them and the Oslo men reaches a very high level of statistical significance.

That the difference exists is further substantiated by the fact that more than 90 % of the captains embarking from Oslo participated in the study. The only unforeseeable bias seems to be that captains embarking from Oslo could differ significantly from captains embarking from other Norwegian sea ports. With this reservation, our data indicate a higher prevalence of occult CHD among sea captains than among Oslo men of similar age. In our hands a pathological exercise ECG is a serious indicator of advanced coronary artery disease even in asymptomatic, apparently healthy middle-aged men (3, 8). For example, a high death rate from CHD and a very high incidence of symptomatic CHD was noted during a 7-a follow-up of asymptomatic men with a pathological exercise ECG (7).

In respect to the serious health problem presented, the following two main questions of CHD epidemiology warrant further scrutiny: (i) Can the difference in CHD prevalence be explained by differences in commonly accepted major CHD risk factors (2, 14), and/or (ii) Is there any evidence which indicates particular occupational hazards for captains as far as CHD is concerned?

We have no data suggesting a particular genetic proneness to CHD among the captains. There was no increase in the prevalence of definite CHD among immediate relatives, particularly not among the young ones. The fact that captains were marginally taller than the Oslo men and had higher spirometric values, a higher physical performance capacity, and a slightly lower blood pressure should indi-

cate, if anything, a lower risk for developing CHD (2, 14). An identical serum cholesterol level among the captains and Oslo men and marginally higher serum triglycerides among the captains suggest no major lipid aberrations. High-density lipoprotein cholesterol was not studied prospectively among the Oslo men, but the data from a subpopulation indicate similar mean levels for the Oslo men and the sea captains (data not shown).

There was no difference in the prevalence of current smokers among the groups, although significantly more Oslo men had never smoked. However, there were significantly more heavy smokers among the captains. It is also noteworthy that the body weight — even corrected for differences in height — was substantially higher among the captains than among the Oslo men. This difference was particularly pronounced above the age of 50 a. It is also noteworthy that the captains' physical performance capacity — although superior to that of the Oslo men at all ages — showed a more rapid decline with age than that of the Oslo men. In this respect the sea pilots were similar to the captains.

Concerning the occupational hazards of being a captain, some fragmentary evidence suggests the presence of considerably higher stress among captains than among the rest of their crew (12), all other officers included. The significance of stress as a mediator of CHD-promoting effects has, however, been debated (15, 17). For sailors on ocean-going ships in general, irregular work hours, varying climatic conditions, and disturbances in major body rhythms pose an unpredictable strain on neurohormonal mechanisms (K Rodahl, unpublished results). Particularly persons more than 40 a of age seem to adapt more sluggishly and poorly (11).

The responsibility and stress caused by all kinds of rules and regulations in international shipping make the situation even worse for captains (12). An impact on health caused by occupational stress has previously been indicated for sea pilots as well in Great Britain and the Federal Republic of Germany (6, 10, 16, 17). In this connection it is interesting to note a significant decrease in pilot mortality in Germany after a decrease in work load was introduced in 1960 (17).

The interpretation of the present data is difficult. In particular, the interpretation is complicated by the fact that the captains were studied immediately preceding embarkation. A study at the time of disembarkation or, preferably, under field conditions would have yielded more valid data. However, a study at disembarkation proved impossible, and resources for field studies were not available. It is conceivable that the environmental effects caused by working on an ocean-going ship are more or less attenuated by the captains' staying at home for variable periods of time.

In the present complicated array of differences between Oslo men and captains, one behavioral pattern may be suggested to exist for captains; ie, a low caloric expenditure during leisure hours and a high caloric intake gradually increase body weight and lower physical performance capacity. In particular this suggestion seems likely in view of the rapid age-related decline in physical performance capacity and the higher body weight among the oldest captains. It is well known that the food on Norwegian ocean-going ships is rich in proteins, calories, and fat.

The interaction of (i) the nutrition/exercise pattern, (ii) the various stress factors mentioned, and (iii) heavy smoking could be one explanation for the high prevalence of occult CHD. This view is substantiated by the fact that 10 of the 11 captains with a pathological exercise ECG were, or had been, heavy smokers and had, on the average, higher serum lipids, a higher body weight, and a lower physical performance capacity than captains with normal exercise ECGs.

Our data are so far inconclusive. However they indicate the presence of a health problem which should be studied further. If our findings can be corroborated, CHD preventive measures should be taken accordingly.

It should be emphasized that we have only dealt with the captains. If the pattern presented is frequently found among this group, it is conceivable that the findings only represent one facet of a major health problem influencing all persons working on ocean-going ships.

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