Welding and Ischemic Heart Disease

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Metal welding and cutting are associated with inhalation of gases and respirable particles. The purpose of this study was to compare the mortality of male welders with that of all gainfully employed men in Sweden regarding ischemic heart disease (IHD). Male welders and gas cutters were identified in the Swedish National Censuses of 1970 and 1990. Two cohorts were established and followed until the end of 1995. The IHD mortality among the welders was compared with that of all gainfully employed men. An increased mortality due to IHD was observed among welders identified in the 1990 Census, SMR = 1.35, 95% confidence limits 1.1–1.6. The observed increased mortality due to IHD was unlikely to be explained by different smoking habits. A general hypothesis linking inhalation of particles to the occurrence of IHD via an inflammatory process is discussed. *Key words*: fibrinogen; inflammation; ischemic heart disease (IHD); welding.

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Metal welding is associated with inhalation of gases and respirable particles. In previous cohort mortality studies of welders the reference incidence mortality was based on national rates. Most of these cohort studies of welders observed a decreased risk regarding ischemic heart disease (IHD). When death rates of welders are compared with death rates of the total population, such a comparison is most often regarded as an underestimation of the true risk, as the general population includes sick and disabled people unable to work. This underestimation is well known as the healthy-worker effect. However, two studies.[1,2] observed an increased mortality among welders due to IHD despite this biased comparison.

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MATERIAL AND METHODS

Male welders and gas cutters were identified in the National Censuses of 1970 and 1990. The first cohort comprised 31 722 welders in the 1970 National Census. In this census employment was identified based on responses to a questionnaire. At least one hour of work during the week 4–10 October 1970 was classified as gainful employment.[3] The cohort was followed from 1970 until December 31, 1995. The second cohort comprised 28,068 welders in the 1990 National Census and was also followed until the end of 1995. In the 1990 Census information about employment was based on data received by Statistics Sweden from employers.[4] The welders were identified with their ten-digit identification numbers, and both cohorts were linked to the Cause of Death Register during the period of follow-up. The referent groups comprised all gainfully employed men identified in the respective censuses. The total numbers of referents in the 1970 and 1990 censuses were 2,047,861 and 2,163,967, respectively. The ages of welders as well as referents were 20–64 years at the time of entry.

Ischemic heart disease (IHD) was defined as code 410-414 of the International Classification of Diseases, 7th and 8th revisions (ICD 7 and 8).

The expected number of deaths in each age stratum was calculated by multiplying the death rate (number of deaths/number of person-years) regarding all gainfully employed in this age stratum with the number of person-years among welders in the same age stratum. The total number of expected deaths is the sum of expected deaths in all age strata. Standardized mortality ratio (SMR) was calculated as the ratio between observed and expected numbers of deaths. The 95% confidence intervals were calculated with an approximative method.[5]

RESULT

An increased mortality due to IHD was found among welders in the 1970 and 1990 censuses, table 1.

DISCUSSION

In previous mortality cohort studies of welders the reference incidence mortality has been based on national rates. Most cohort studies of welders have observed a decreased risk regarding diseases of the circulatory system and IHD.[6-8] When death rates of welders are

TABLE 1. Standardized Mortality Ratios (SMR) of IHD in Two Cohorts of Welders and Gas Cutters Followed until the End of 1995

Cohort	Observed	Expected	SMR	95% CI
1970 Census	2,156	2,028.9	1.06	1.02–1.11
1990 Census	102	75.3	1.35	1.10–1.64

compared with death rates of the total population, such a comparison is most often regarded as an underestimation of the true risk, as the general population includes sick and disabled people unable to work. This underestimation is well known as the healthy worker effect.[9] However, two studies.[1,2] observed an increased mortality among welders due to IHD despite this biased comparison. A Swedish case–control study of 26,847 men with myocardial infarction found an increased risk among welders and gas cutters.[10]

Smoking is strongly associated to IHD, and male smokers have a risk ratio of 2 compared with non-smokers.[11] Smoking habits were surveyed in the male population aged 20–65 years between 1986 and 1990. The total sample comprised 8,474 men and the number of welders was 112. In the general population 29% were current daily smokers, compared with 42% among the welders. To estimate the excess risk of IHD due to smoking habits among male welders compared with males in the general population, expected incidences were calculated as proposed by Axelson and Steenland.[12] I_{mg} is the incidence for men in the general population regarding IHD. I_{mw} is the incidence for male welders, and I_o is the incidence for non-smoking men. RR_s is the risk ratio for IHD when comparing smokers and non-smokers.

$$I_{mg} = I_o \times 0.71 + RR_s \times I_o \times 0.29$$
$$I_{mw} = I_o \times 0.58 + RR_s \times I_o \times 0.42$$

Based on the available data, the estimated relative risk (I_{mw}/I_{mg}) was 1.10 when welders were compared with the general population. The observed relative risk in the first cohort could be explained by differences in smoking habits. However, the increased relative risk in the second cohort followed from 1990 to 1995 is unlikely to be explainable by smoking habits. It is also unlikely that the working conditions were worse in 1990 compared with 20 years earlier.

Information about employment was gathered in different ways between 1970 and 1990. It has been estimated that the number of employed is 5% higher in the 1990 Census due to differences of information retrieval.[4] Thus, the 6% higher number of referents in the Census 1990 compared with Census 1970 could be consistent with the differences of data retrieval. Consequently the decrease in number of welders between 1970 and 1990 is likely an underestimation of the true decrease.

Welders are sometimes exposed to metal fumes associated with fever. Zinc oxide is the best-known inducer of metal-fume fever. Inhalation of zinc oxide fumes increases the plasma concentration of interleukin-6.[13] Interleukin-6 is known to stimulate hepatocytes to produce and secrete fibrinogen.[14] High plasma level of fibrinogen is an established risk factor for coronary heart disease.[15] A general hypothesis has linked inhalation of particles to the occurrence of IHD in the following way. Inhalation of air pollutants retained in the lungs will hypothetically create a low-grade inflammation associated with an increase in plasma fibrinogen. The high concentration of fibrinogen and possibly other factors associated with blood coagulation will increase the likelihood for blood clotting and thereby the risk for myocardial infarction and IHD.[16,17]

Some welding methods such as the metal inert gas (MIG) and tungsten intert gas (TIG) methods used to weld aluminum or stainless steel are associated with significant ozone exposures.[18] Ozone exposure of 0.1 ppm for 6 hours increased the level of interleukin-6 in the bronchoalveolar lavage.[19] This increase might result in higher concentrations of plasma fibrinogen, but this possibility has not yet been investigated, to our knowledge.

In Norway three fatal cases of pneumonia with septicemia have been reported since 1997. All three men had been exposed to welding fumes immediately before they fell ill.[20] Nonfatal pneumonia after exposure to fumes from cutting, grinding, and welding has also been observed in Norway. On one occasion, three workers were hospitalized with lobar pneumonia, while six were treated as outpatients for lower-repiratory-tract infection, after reconstruction work inside the hull of a ship.[21] An increased mortality due to pneumonia has also been observed among welders in some epidemiologic studies.[6,22] Thus it seems that welding fume exposure may increase the susceptibility to pneumonia.

Chronic bronchitis is more prevalent among welders compared with different referent groups.[18] In the original Framingham Heart Study,[23] chronic cough was associated with the occurrence of myocardial infarction after adjusting for age, gender, smoking, FVC, diabetes mellitus, systolic blood pressure, angina pectoris, and total cholesterol level. In a Finnish study, chronic bronchitis was also associated with an increased risk regarding coronary disease after adjustment for three major risk indicators.[24] A very tentative conclusion from these results could be that exposures associated with chronic bronchitis are also associated with IHD.

Heart rate variability (HRV) reflects the interplay between the sympathetic nervous system and the parasympathetic nervous system. Reduced HRV is a predictor of increased risk for cardiovascular mortality and morbidity.[25] In a study of 21 53-to-87-year-old active Boston residents, particle and ozone exposures reduced HRV.[26] Thus, reduced HRV might be another mechanism associated with IHD.

All welders were currently exposed when the two cohorts were established in 1970 and 1990. As time goes

by, an increasing proportion of welders will leave their work by moving to less exposed occupations and by retirement. The increased IHD-related mortality among the welders in the 1990 census might be explained by the fact that this cohort contained a large proportion of currently exposed welders who had been exposed during the entire follow-up period. With a further increasing follow-up, the proportion of currently exposed welders will decrease. Thus, the other cohort contained a larger proportion of retired welders who, during at least a part of the follow-up period, had not been exposed to welding fumes. The effects of welding fume inhalation might be analogous to those of smoking. Ex-smokers are known to have a lower IHD mortality compared with current smokers.[11] Further studies are needed to investigate the relationship between current welders and ex-welders with respect to IHD mortality.

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