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Two Welsh Surveys of Blood Lead and Blood Pressure

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The relationship between blood pressure and blood lead was examined in two population samples. One of these consisted of 1137 men aged 49 to 65 years, the other of 865 men and 856 women aged 18 to 64 years. Neither population had any known important exposure to lead, and the 95% ranges of blood lead levels were 6 to 26 µg/100 mL and 6 to 23 µg/mL in the men and 5 to 18 µg/100 mL in the women.

No significant relationship between blood pressure and blood lead was detected in either of the population samples, and the regression coefficients suggest that if there were a real effect, then the mean difference in blood pressure per 10 µg difference in blood lead is likely to be 0.7 mm Hg in both systolic and diastolic pressures. In the survey of 1137 men, the rise in blood pressure was measured during the cold pressor test. This test is likely to be affected if lead were to affect neurogenic mediators of blood pressure. The mean change in systolic pressure was 24 mm Hg and the 95% range was –6 to 60 mm Hg, but there was no evidence of any association with blood lead level.

Introduction

There has been considerable interest recently in lead as a possible determinant of blood pressure following a report by Pirkle and his colleagues (*1*), who described a positive relationship and went on to estimate the number of deaths from cardiovascular disease that could be attributed to lead. The evidence in the literature is, however, confusing, some studies giving evidence suggestive of a positive relationship (*1–3*) and others (*4,5*) giving no convincing evidence. We present here data from two large cardiovascular surveys in Wales in which data were collected on blood lead and blood pressure.

Methods

The Caerphilly Collaborative Heart Disease Studies (*6,7*) are based on a cohort of approximately 2500 men aged 49 to 65 years, living in Caerphilly, a small mining town in the South Wales valleys. The data reported here came from the first 1164 men seen in the first follow-up examination of this cohort. A wide range of factors of possible relevance to cardiovascular disease, including blood lead, are being measured. The cohort is being followed and incident cardiovascular and other disease is being recorded.

Blood lead was measured on a sample of venous blood from each subject using atomic absorption spectrophotometry. Blood pressure was measured with a random zero muddler sphygmomanometer (*8*) after a 5-min rest. The rise in blood pressure during a cold pressor test (*9*) was measured with an automatic sphygmomanometer (*10*). In this test the hand and wrist are immersed in water at 4°C for 1 min. The consequent rise in blood pressure has been shown to be predictive for ischemic heart disease (*11*).

The Welsh Heart Programme (*12,13*) was a survey throughout the Principality of Wales, completed in 1985. A stratified, cluster, random sample of 21,000 households was drawn for the main enquiry and from this a subsample of approximately 2000 adults of both sexes, aged 18 to 64 years, were seen for clinical measurements. Blood pressure was measured after a 5-min rest, using a random zero muddler sphygmo-

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manometer. Blood lead was measured as in the Caerphilly survey, in the same laboratory.

Results

Complete data are available for 1137 men in the Caerphilly study. The geometric mean blood lead in this study was 12.7 μg/100 mL and the 95% range, after log transformation, was 6 to 26 μg/100 mL. The mean rise in blood pressure during the cold pressor test was 24 mm Hg systolic, with a 95% range of −6 to 60 mm Hg, and 11 mm Hg diastolic, with a 95% range of −7 to 33 mm Hg. On a logarithmic scale the pressor effect of the test was almost constant at all levels of blood pressure (mean rises of 15% systolic and 12% diastolic), and so the results of this test are best analyzed in proportional terms.

Data are available for 865 men and 856 women seen in the Welsh Heart Programme. Mean blood lead levels after log transformation are 11.6 and 9.0 ug/100 mL, and 95% ranges are 5.7 to 23.3 μg/100 mL in males and 4.5 to 18.3 μg/100 mL in women. There is a significant relationship with age, equivalent to a rise of 0.6 μg/100 mL blood lead in every decade in men and 0.8 μg/100 mL every decade in women.

Figure 1 displays the resting systolic blood pressures, and Figure 2 displays resting diastolic pressures in the two surveys. There is little evidence of any relationship. Table 1 shows the regression coefficients of blood pressure on blood lead. Transformation of the data to logarithms had little effect on the relationships and so, to facilitate interpretation, the coefficients shown are those derived from untransformed data. None of the coefficients approaches conventional levels of significance, and they suggest that, even if there were a relationship, the effect of blood lead on blood pressure would be very small. Thus, taking the larger of the coefficients for systolic and the largest for diastolic pressures, the mean rise in blood pressure per 10 μg difference in blood lead is likely to be around 0.7 mm Hg in both systolic and diastolic pressures.

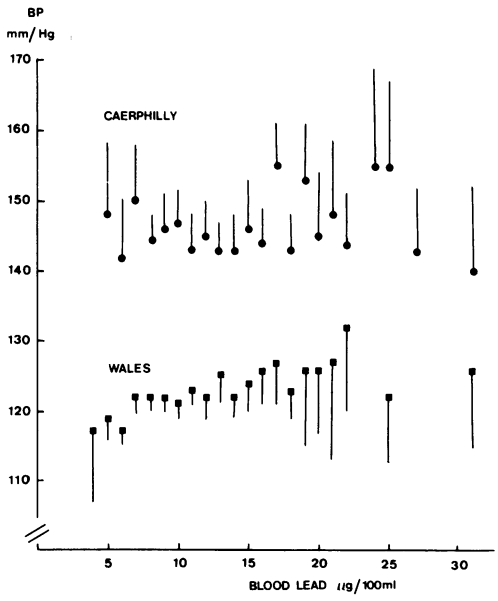

FIGURE 1. Mean systolic blood pressures in the sample of 1137 men in the Caerphilly sample and in the 1721 subjects seen in the Welsh Heart Programme (Wales). The data for the latter study have been standardized for sex and to a common mean age of 40 years. The lines represent 95% confidence intervals and for clarity have been entered on only one side.

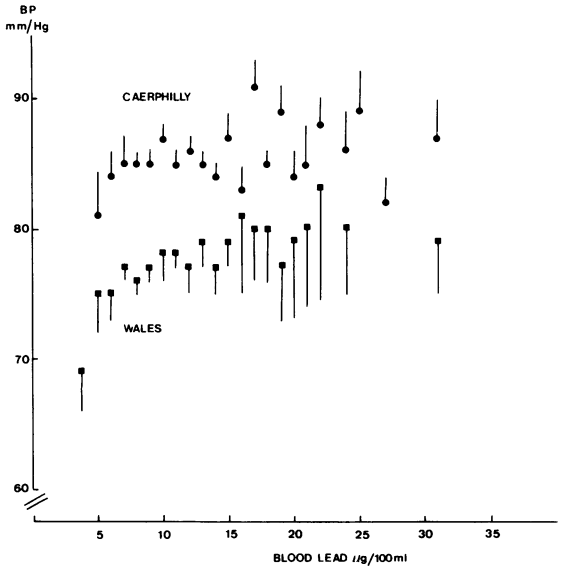

FIGURE 2. Mean systolic blood pressure and 95% confidence intervals (shown on only one side of each mean). Other details as for Fig. 1.

Table 1. Regression coefficients of blood pressure on blood lead in two surveys.[a]

		Regression coefficients, ± SE	
Study	Sex	Systolic pressure	Diastolic pressure
Caerphilly	M	0.077 ± 0.126	0.049 ± 0.068
Welsh Heart Programme	M	0.050 ± 0.108	0.068 ± 0.069
	F	0 ± 0.135	0.048 ± 0.093

[a]Blood pressure, mm Hg; blood lead, μg/100 mL.

Another way of examining these data is to compare the proportions of subjects who might be considered to be hypertensive at various levels of blood lead. This approach is most appropriate with the Caerphilly subjects, as these are much older than the majority of the subjects in the Welsh Heart Programme, and a substantial proportion of them have high blood pressures. In the total cohort, 26% have systolic pressures of 160 mm Hg or greater. In the men with blood lead levels of 25 μg/100 mL or greater, 25% have blood pressures above this level, and in those with blood lead levels over 30 μg the proportion is only 14%.

Table 2 summarizes the relationship between the rise of blood pressure in the cold pressor test and blood lead. Both coefficients are very small, both are negative, and neither is significant.

Table 2. Regression coefficients for the rise in blood pressure during the cold pressor test and blood lead level.

Pressure	Regression coefficients ± SE
Systolic	−0.071 ± 0.126
Diastolic	−0.077 ± 0.065

Discussion

A number of animal studies have detected significant increases in systolic blood pressure on exposure to lead. Several conclusions from these are of possible relevance to the present data. First, increases in blood pressure appear to follow low-level lead exposures and do not seem to occur with high levels (*14*). This is relevant to the fact that, although the blood lead levels of the subjects in the present report show a wide range, they are all relatively low. Then, although the evidence is not consistent, it has been suggested that an effect of lead on blood pressure only occurs in male animals (*15*). Although we do present some data for females, most of our subjects are male. Further strengths of our data include the fact that they are all representative population samples drawn, in the one study, from the whole of the Principality of Wales, and, in the other, from a typical small Welsh town. Our subjects would therefore appear to be well suited to test the proposed hypothesis.

The relationships that we detect between blood pressure and blood lead are extremely weak and are not statistically significant. The mean difference in blood pressure that corresponds to the 95% range observed in blood lead in the Caerphilly sample (6–26 μg/100 mL) is only 1.5 mm Hg systolic and 1.0 mm Hg diastolic. Standardization of these for confounding factors, in particular alcohol intake, but also body mass index and cigarette consumption, would undoubtedly reduce these figures even further.

A number of mechanisms by which lead might affect blood pressure have been considered, but a large number of animal studies have led to no certain conclusions. In a review of the evidence, Sharp et al. (*16*) judged that neurogenic mediators may be involved, leading to an alteration in vascular reactivity. If this were true then it is not unreasonable to expect an effect to be apparent on the cold pressor test. On the other hand, human occupational studies (*17,18*) have suggested that renal damage could be a mechanism in lead-induced hypertension in workers heavily exposed to lead, and this raises the possibility of the renin-angiotensin axis being involved. The use of the cold pressor response would be an inappropriate way to test this hypothesis; however, Sharp et al. (*16*) judge that renal effects are unlikely to be the primary mechanism by which elevations in blood pressure might be produced by lead.

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