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BLOOD-LEAD AND HYPERTENSION

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...mmary Blood and tap-water lead levels were examined in 135 hypertensives and 135 ...and sex matched normotensives. Among male hypertensives there was a significant excess of cases with high ...d lead levels and a similar but statistically non-signi...t trend was found amongst female hypertensives. A ...tive correlation was found between blood-lead and ...water lead. It is concluded that in the West of Scot... high blood-pressure is associated with high blood-...d levels, which might explain the high prevalence of ...iovascular disease in the area.

Introduction

HYPERTENSION and cardiovascular diseases are ...mmon in areas with soft drinking-water supplies.[1-4] ...e acidic nature of soft water leads to increased plumb...solvency,[5] so that in areas like the West of Scotland ...ere the drinking water is extremely soft and is fre...ently delivered and stored in lead plumbing systems ...gh lead levels may occur in the water.[6] It is not known ...ether these high levels of water lead may explain the ...gh prevalence of hypertension and cardiovascular dis...se in these areas.[7,8] Several workers have demon...ted a significant positive correlation between the ...d content of the drinking water supply and blood-lead ...els.[6,9,10] Furthermore, blood-lead levels greater than ...conventional upper acceptable limit of 2 µmol/l were ...nd in 4 out of 71 subjects (5·6%) studied in urban ...sgow, none of whom had clinical evidence of lead ...soning.[6] In that study there were 6 cases with diasto... blood-pressures of 95 mmHg or more who had a ...her mean blood-level of 1·61 µmol/l than in normo...ive cases studied (mean blood-lead 1·09 µmol/l). No statistical significance could be attached to these small numbers.

To investigate further the possible association of high blood-level levels with hypertension we have studied an unselected group of hypertensives and normotensive controls, detected at a screening survey in Renfrew, Scotland.[11]

Methods

Renfrew is an urban burgh on the outskirts of Greater Glasgow. Much of the mains water-supply is delivered in lead pipes and in many of the older tenement blocks in the area, storage tanks for drinking-water are also lead-lined. There are no local industries with particular occupational hazards from lead exposure.

In 1972, an epidemiological screening survey was conducted amongst residents aged 45–64 years, and diastolic blood-pressures of 100 mmHg or more were found in 21·2% of the population studied.[11] After screening, a follow-up clinic was established to investigate and manage the hypertensive patients and carry out clinical research into hypertension.[12] The study of blood-lead was confined to the first 135 cases to attend the clinic whose diastolic blood-pressures were 100 mmHg or greater at screening or who had had hypertension diagnosed previously by their family doctors. In all cases this level of hypertension was confirmed at the clinic. The 135 hypertensives (74 males, 61 females) were compared with 135 age and sex matched normotensive subjects selected randomly from the same population. The diastolic blood-pressure of controls was persistently less than 90 mmHg. No subject was occupationally exposed to lead.

Blood-pressures at screening and in the clinic were measured using the London School of Hygiene and Tropical Medicine sphyg momanometer,[13] diastolic blood-pressures being taken at the point of final disappearance of the diastolic sound (Korotkoff v). A 10 ml specimen of blood was taken for lead analysis into a heparinised plastic tube and subjects were provided with a 250 ml lead-free container and asked to return with the first sample of kitchen cold tap-water taken in the morning. Only 90 hypertensives and 119 normotensives provided tap-water specimens, although blood-lead levels were available in all cases. Blood and water lead levels were measured by flameless atomic absorption spectrophotometry (Perkin-Elmer 306: HGA 72). Data on smoking habits, obesity index, and plasma-creatinine concentrations were available in all cases from the preliminary screening examination.

Results

Men and women were analysed separately. Fig. 1 and 2 show the frequency distribution curves for blood-lead concentrations. The mean blood-lead concentrations for hypertensive and normotensive men were 1·31 (±0·54

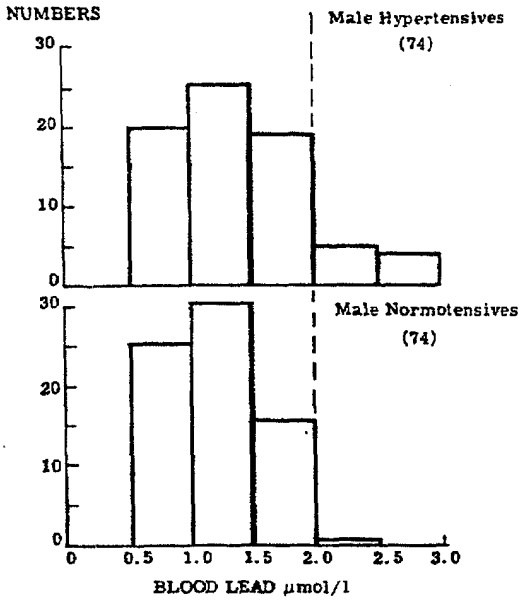

Fig. 1—Distribution curves for blood-lead levels in normotensive and hypertensive men.

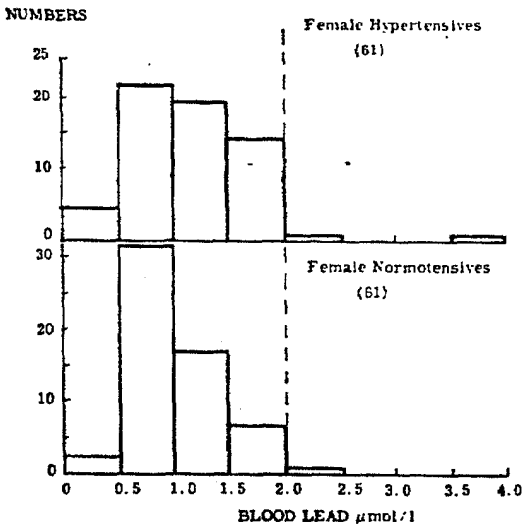

Fig. 2—Distribution curves for blood-lead levels in hypertensive women.

S.D.) and 1·14 (±0·38 S.D.) μmol/l, and for hypertensive and normotensive women 1·09 (±0·54 S.D.) and 0·94 (±0·39 S.D.) μmol/l.

High blood-lead levels (greater than 2 μmol/l) were found in 8·2% of hypertensives and 1·5% of normotensives (table I). Significance tests aimed at detecting a simple shift of distribution, such as Student's *t* or non-parametric sign tests, were unlikely to detect the significance of an excess of raised blood-levels in one group compared with another. Instead, formal tests of significance were based on table II. Amongst male subjects there were 38 (35+3+0) pairs of normotensives and hypertensives with blood-lead levels within the same range. If there was no association between blood-lead and raised blood-pressure, then the normotensive in about half of the remaining 36 pairs would be expected to have a higher blood-lead than the hypertensive. In fact this happened in only 11 pairs. Reference to the binomial distribution yielded a two-tailed significance level of $P<0·05$. Thus the observed association between blood-lead and hypertension amongst men is statistically significant. Amongst women, these tests showed a similar trend but did not reach statistical significance.

The groups studied were selected in terms of age and sex but, as seen from table I, there appeared to be a tendency amongst hypertensives and normotensives for high blood-lead levels to occur in older subjects, although

TABLE I— BLOOD-LEAD, AGE, BLOOD-PRESSURE, SMOKING, OBESITY, AND PLASMA-CREATININE IN SUBJECTS STUDIED

	Normotensive, with blood-lead:*			Hypertensive, with blood-lead:		
	Normal	Borderline	High	Normal	Borderline	High
Male:						
No.	57	16	1	46	19	9
Mean age (yr)	55·5 (± 5·8)	54·5 (± 5·2)	60	55·5 (± 5·4)	56·1 (± 5·8	57·7 ± 7·4
Mean diastolic blood-pressure (mmHg)	75·7 (± 6·5)	79·4 (± 6·9)	70	111·0 (±12·7	109·0 (± 9·3)	111·6 ±12·6
Mean plasma-creatinine (μmol/l)	100·7 (±16·7)	93·4 (±13·3)	88·4	107·6 (±22·9)	104·7 (±14·1)	106·1 (±20·7
Mean % obesity index	−1·1 (±11·1)	+2·9 (± 8·9)	−16·8	+9·9 (±16·1)	+10·5 (±11·4)	+9·3 ±11·6
% smokers	45·6	43·6	100	26·2	36·8	66·6
% w water lead >100 μg/l	12·5	61·5	0	29·7	30·8	4[illegible]·9
Female:						
No.	53	7	1	45	14	2
Mean age (yr)	56·2 (± 5·9)	59·0 (± 6·5)	61	56·4 (± 6·0	56·4 (± 6·1	64·5 ± 1·4
Mean diastolic blood-pressure (mmHg)	[illegible]	[illegible]	84	112·2 ±10·4	100·0 ± [illegible]	12[illegible]·5 ± 3·5
Mean plasma-creatinine (μmol/l)	88·4 (±17·6)	92·2 (± 8·8)	106	88·4 (±17·7	88·4 (±17·7	106·1 (±17·7
Mean % obesity index	−3·5 (±16·9)	−1·8 (±10·9)	−10·2	+16·7 (±22·7	+19·9 (±29·9	+5·8 ±25·4
% smokers	43·4	42·8	0	21·7	21·4	50
% w water lead >100 μg/l	11·1	57·1	100	21·9	27·3	100

* Normal=0–1·4 μmol/l.
Borderline=1·5–1·9 μmol/l.
High = ≥2·0 μmol/l.
Division factor for conversion from blood-lead μmol/l to μg/100 ml=0·0483.
Figures in parentheses=S.D.
% Obesity index=% variation corrected for height, from mean for population in Renfrew.

TABLE II—COMPARISON OF BLOOD-LEAD LEVELS IN PAIRED NORMOTENSIVE AND HYPERTENSIVE MEN

...tensive ...d-lead ...els	Hypertensive blood-lead levels			Total
	Normal 1·5 µmol/l	Borderline 1·5–1·9 µmol/l	High >2·0 µmol/l	
2 µmol/l	1	0	0	1
...ne 1·9 µmol/l	10	3	3	16
...1·5 ...l	35	16	6	57
	46	19	9	74

in the narrow 20-year age range there was no correlation between blood-lead and age (male hypertensives, 0·05). No correlation was found between the level ...ood-pressure and blood-lead amongst hypertensives ...es, r=—0·02; females, r=0·02) and no correlations ... found with plasma-creatinine and blood-lead ...·06). 6 hypertensives had evidence of renal failure, ... raised plasma-creatinine concentrations; 1 had ...onic pyelonephritis and 1 had hypertension following ...och-Schoenlein purpura. None of these 6 had high ...d-lead levels.

Whilst the proportion of hypertensives who were ...se was greater than the normotensives, no relation... was found between blood-lead and obesity (male ...ertensives, r=0·05). It is of interest that there were ...re non-smokers amongst the hypertensives than the ...motensives.

Water-lead concentrations greater than 100 µg/l (48 µmol/l) (the World Health Organisation's upper ...eptable limit) were found in 26·6% of hypertensives ...d 20·1% of normotensives. There was a relationship ...tween water lead and blood-lead. Significant correla...ns were found between water and blood lead ...ongst normotensives (males, r=0·372, P<0·01; ...ales, r=0·359, P<0·01) but not amongst hyperten...es (males, r=0·065; females, r=0·120).

Discussion

Workers in a lead-related industry have been ...ported to have an excess death-rate from cerebrovas...lar disease,[14] although Cramer and Dahlberg[15] were ...able to find a raised prevalence of hypertension. Also ... chronic plumbism, other changes have been reported, ...cluding intranuclear inclusion bodies in the proximal ...nal tubular cells, although renal function may be ...pared.[16 17] However, after prolonged low-grade expo...re, renal failure, hyperuricæmia, and gout may ...cur.[18]

The present study confirms the data of Beattie et al.[6] ...howing a possible association of chronic low-grade ...posure to high-water-lead with hypertension. Elwood ... al.[2] in Wales confirmed a negative association between ...ater hardness and cardiovascular mortality and found ... weakly positive correlation between water lead and ...tal cardiovascular mortality. However, these workers ...ave since failed to find consistently higher water-lead ...vels in subjects dying of cardiovascular disease com...ared with other causes.[19]

There are several possible hypotheses to explain the ...nding of an association between blood-lead and raised ...ood-pressure. Chronic low-grade exposure to lead in ...nking-water may in some way lead to development of hypertension, possibly the mechanism being effects of lead on renal function. An alternative hypothesis is that hypertensives tend to develop high blood-lead concentration, either by drinking more water or by chronic retention of lead, possibly due to reduced renal clearance as part of a hypertensive nephrosclerosis. The lack of association of raised blood-lead with raised plasma-creatinine does not support either of these possibilities. A third hypothesis is that chronic ingestion of lead in drinking-water results in higher frequency of raised blood-lead levels with advancing age, and since hypertension also occurs more commonly in older subjects, there might only be a chance association between these two age-related indices. Suppression of renin release, as is found in up to 30% of hypertensives, has also been reported in cases of chronic plumbism, even in the absence of hypertension.[20 21] Renin suppression is also age-related, there being an inverse correlation between renin and age.[22–24] This suppression has been taken as evidence of the development of hypertensive nephrosclerosis.[25 26] However, in the age-matched normotensive group studied here, high blood-lead levels were not common, and thus the third hypothesis is less likely.

It therefore remains possible that the added combination of soft drinking-water and a high water-lead concentration, as seen in the West of Scotland, may be a factor to explain the high prevalence of hypertension and cardiovascular disease in the area. Further studies of blood-pressure and blood-lead in a larger population are necessary to resolve this point.

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