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Effects of Serum Iron Status on the Relationship between Manganese and Iron transport proteins in Iron Foundry Workers

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Abstract

Iron foundries deal with the tapping and transport of molten iron and charging of furnaces. This creates exposure to iron oxide and other metal oxide fumes. The aim of this study was to evaluate the alterations in biochemical parameters related to iron metabolism in iron foundry workers. In the study 50 iron foundry workers engaged in daily foundry work were randomly selected from an iron foundry in Narol, Ahmedabad. The results were compared with age, sex matched employees of the foundry engaged in other work and not exposed to fumes. Results showed higher manganese and iron levels in subjects engaged in foundry work compared to controls. The proteins ferritin and transferrin, associated with iron metabolism were significantly altered compared to controls.

Key words: Iron foundry, manganese, iron oxide, ferritin, transferrin

INTRODUCTION

A foundry is a factory which produces metal castings from either ferrous or non-ferrous alloys. The various processes in a foundry gives rise to heat, molten metal splashes, noise, gases and vapours. If these hazards are not controlled or contained

serious health effects in exposed workers can result. The body must protect itself from free iron, which is highly toxic as it participates in chemical reactions that generate free radicals.[1] Iron is directly toxic to cells, and much interest has centred on the role of Fe (II) and Fe(III) in initiating and catalysing free-radical mediated reactions." Much of the cell damage is mediated by membrane disruption, particularly that of the lysosomal membrane attributable to iron-catalysed lipid peroxidation.[2]Transporting iron from one organ to another is accomplished by the reversible binding of iron to the transport protein, transferrin, which will then form a complex with a highly specific transferrin receptor (TfR) located on the plasma membrane surfaces of cells. Intracellular iron availability is regulated through the increased expression of cellular TfR concentration by iron-deficient cells. Ferritin is the major iron-storage compound: its production increases in cells as iron supplies increase.[3] Furnace men are exposed to manganese (Mn) in the workplaces from both naturally occurring processes and processing activities. High exposure to airborne manganese may tend to accumulation of the compound in the basal ganglia of the brain. Researchers illustrated that the neurological disorder of manganese (`manganism') bears many similarities to Parkinson's disease for exposed workers.[4] The objectives of the study were to evaluate the alterations in biochemical parameters related to iron metabolism in iron foundry workers.

MATERIAL AND METHODS

50 iron foundry workers engaged in daily foundry work were randomly selected from iron foundry in Narol, Ahmedabad as the exposed group. The foundry workers, of whom 06 were females and 19 males, worked 7-8 hrs per day with the average employment history of 11.1 years (range 0.5-30 years). A control group of 25 foundry workers were recruited (17 males and 08 females) , frequency-matched to the worker group by sex, age and work shift distribution, from the same factory, who have been employed in the professions other than foundry processes and not exposed to fumes and hazards present in foundry enviornment. The mean age was 40.5 years (range: 21-68 years) and 35.4 years (range: 19-52 years) respectively for foundry workers and controls. Subjects in both groups at the time of interview had reported no exposure to other toxic substances, radiation therapy or substance abuse. Subjects who had taken special medications which would interfere with iron metabolism such as vitamin D, aspirin or herbal medication were excluded from the study. Statistical analysis: Differences in the parameters between the groups were analysed by t test. Variables were presented as mean ± S.D. The accepted level of significance for all statistical analyses used in the study was $P \leq 0.05$ (Two tailed P value).

Following parameters were assessed:

1. SERUM IRON and TIBC: Colorimetric method
2. SERUM MANGANESE: Spectrophotometric catalytic method
3. SERUM TRANSFERRIN: Immunoturbidimetric end point method
4. FERRITIN: Enzyme immunoassay

Table 1: Serum concentration of various parameters - Iron, Manganese, Ferritin, Transferrin in subjects.

		Foundry workers	Controls	P value
	Male	3.17± 0.64	1.66± 0.26	< 0.001 (S)
Mn (µg / L)	Female	2.95± 0.51	1.91± 0.34	< 0.001 (S)
	Male	1795.7 ± 105.9	1475.0 ± 83.4	< 0.001 (S)
Fe (µg / L)	Female	1416.5 ± 98.6	1375.6 ± 72.8	0.38 (NS)
	Male	269.0 ± 82.6	151.0 ± 42.3	< 0.001 (S)
Ft (ng/ml)	Female	73.9 ± 11.5	123.0 ± 54.4	< 0.001 (S)
	Male	240.0 ± 42.9	216.0 ± 16.8	< 0.04 (S)
TRF (mg/dl)	Female	231.0 ± 30.3	219.0 ± 12.7	0.33 (NS)
	Male	235.0 ± 55.2	303.0 ± 38.6	< 0.0002 (S)
TIBC (µg/ dl)	Female	255.0 ± 40.7	315.0 ± 55.1	0.04 (S)

Values expressed as mean ± S.D. S: Significant NS: Non- Significant

Table 2: Occupational problems reported by iron foundry workers

PROBLEMS	PERCENTAGE OF WORKERS
Skin irritation	2/25 (8 %)
Respiratory problems	2/25 (8 %)
Eye problems	1/25 (4 %)
Headache	7/ 25 (28 %)
Chest / Throat pain	2/ 25 (8 %)
Tetanus	0/25 (0%)
Backache	9/25 (36 %)

Table 3: Representation of Types of exposures, duration of subjects in Iron Foundry.

Exposures and Duration of Exposure	**% values of Exposed Workers**
1.FUMES/DUST: Always	11/25 (44)
2.Duration Of Exposure To Fumes/Dust (Hrs/Day) <8	18/25 (72)
3.EXCESSIVE NOICE: Always	6/25 (24)
4.Duration Of Exposure To Noise (Hrs/Day) <8	14/25 (56)
5.DIRECT HEAT: Sometimes	11/25 (44)

DISCUSSION:

Since manganese exposure alters iron metabolism we hypothesised that changes in serum concentrations of iron related proteins may be used as the potential indicators for manganese exposure. Our data suggest that the foundry workers had significantly higher serum levels of both manganese and iron as compared to control subjects. Not only were serum iron levels significantly higher in foundry workers than in controls, but also increased iron levels among foundry workers were significantly influenced by the years of experience as a foundry worker. Altered serum iron levels among foundry workers could be attributable to exposure to iron oxide and other metal oxide fumes. Exposure to fumes may have a significant impact on serum concentration of iron and certain proteins associated with iron regulation and metabolism. Under

normal physiological conditions, the iron homeostasis is regulated by a group of proteins involved in iron metabolism such as ferritin and transferrin.[5]

Manganese may compete with iron for the Fe-S cluster in the active centre of iron regulatory proteins. Such a competition would increase the proteins ability to bind to mRNA encoding transferrin receptor and ferritin, which in concert with an enhanced transport of iron at brain barriers may promote the cellular overload of iron in brain, subsequently leading to iron initiated neuronal oxidative damage.[6]

In the current study, serum ferritin levels among foundry workers were increased suggesting a systemic overload of iron. These results suggest that exposure to fumes emitted in iron foundries has led to an altered status of serum ferritin and transferrin. While these changes could be a direct result of elevated serum iron among iron foundry workers, it is interesting to note that a decreased serum TIBC level is significantly associated with the increase of serum manganese concentrations, suggesting an involvement of manganese in iron metabolism and regulation.[7]

The apparent wide variations in manganese uptake and in susceptibility to manganese are likely to be due to an interaction with iron metabolism. Individuals who take up an increased amount of iron from the gut will also take up an increased amount of manganese. Results in this study showed that exposure to the welding fume significantly increased the concentration of iron in serum. This increase could partly be attributed to the possible action of manganese on iron metabolism.[8]

CONCLUSION

In summary, the results from this study demonstrate that the foundry workers had serum concentrations of manganese and iron higher than controls. The proteins associated with iron metabolism like ferritin and transferrin were significantly altered compared to controls. Moreover, we suggest that serum manganese concentrations may serve as a useful biomarker for recent exposure to air borne manganese

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