Egyptian Journal of Occupational Medicine, 2007; 31 (1) : 107 - 121

ASSESSMENT OF RESPIRATORY AND RENAL FUNCTIONS AMONG GAS METAL ARC WELDERS AND THEIR RELATIONS WITH CHROMIUM EXPOSURE

By

Helal SF [1], Arafaa AM [2], and Afify M [3]

FROM

Industrial Medicine and Occupational Diseases department (1),

NECTR (2) , NRCD Biochemistry Department (3)

Faculty of Medicine-Cairo University

ABSTRACT

Background: Welding is the most common way of permanently joining metal parts. Welders use many types of welding equipment set up in a variety of positions. Arc welding is the most common type. Welding, soldering, and brazing workers often are exposed to a number of hazards, including the intense light created by the arc, poisonous fumes, and very hot materials.**Objective:** The aim of the present study was to investigate some of the health hazards among gas metal arc welders with special emphasis on renal and lung examination and to monitor the level of chromium in blood and urine, and studying its relation with the renal condition. Our aim was also to detect early renal affection by measuring of B^2 microglobulin in urine. **Subjects and methodology:** This study was conducted in three welding shops in El Manial, and El Maadi, in Cairo. The study was accomplished during the months of October and November, 2006.The studied group comprised 18 workers in the metal arc welding shops. They were adult men aged between 18-42 years (26.5 ±7.8), working on the basis of 12 hours/day with one day off per week. None of the workers used any protective equipment during working hours. A referent group of 20 males matched for age that ranged from 21-41 yrs., (26.2±6.38), sex, socio-economic status, smoking habits, selected from relatives of the Kasr El Eini hospital patients, were also enrolled in our study. The following investigations were performed after taking individual consent: (A) All workers were interviewed using a special questionnaire including occupational history .(B) Ventilatory function tests were done measuring FVC, SVC, FEV1%, FEV1/FVC, and PEF. (C) Beta2 Microglobulin in urine .(D) Blood and urine chromium levels.(E) Urea and creatinine and fasting serum sugar level. All investigations were done at The Biochemistry department at The National Research Centre, Dokki. **Results:** showed a statistically significant difference between the exposed and the control groups as regards spirometric evaluation of FEV1/FVC, PEF%, and MEF 25-75%. Our results revealed also a statistically significant difference between the exposed and the control groups as regards the level of chromium in blood and urine and the level of B2 microglobulin in urine. There is also a statistically significant difference between both groups as regards the blood level of urea and creatinine, but there is no statistically significant difference between both groups as regards the level of fasting blood sugar. Our research showed a statistically significant difference between the exposed and the control groups as regards the occurance of metal fume fever. Among the exposed group there was no statistically significant difference between smokers and non smokers as regards the level of chromium in blood and urine, the level of B^2 microglobulin in urine and there was no statistically significant difference between both groups as regards renal function tests and the level of fasting blood sugar level, but there was a statistically significant difference between both groups as regards FVC% and SVC%. Our results showed that there was no statistically significant correlation between the duration of exposure to chromium in welders and all investigations done, but there was a statistically significant correlation between the level of chromium in blood and spirometric parameters and the levels of chromium in urine, B^2 microglobulin in urine, urea, and creatinine. **Recommendations:** From the present study we recommend environmental monitoring in different areas in the welding shops to ensure that permissible levels of different hazardous agents are not exceeded. Pre-employment and periodic medical examinations must be performed to exclude those susceptible to lung and renal diseases. Personal protective clothes e.g. gloves and respiratory protective equipment should be used in welders. Health education programs of workers about hazards of exposure to harmful agents and proper measures for protection is essential and this includes training programs to raise awareness among welders. Effective local exhaust ventilation to remove hazardous gases and fumes is essential. Finally, urinary or blood chromium can be used as indicators of recent chromium exposure among welders.

Key words: Metal arc welders- Chromium- B2 microglobulin- MFF.

Introduction

Gas Metal-Arc Welding (GMAW), also called Metal Inert Gas (MIG) welding, shields the welding zone with an external gas such as argon, helium, carbon dioxide, or gas mixtures. Deoxidizers present in the electrode can completely prevent oxidation in the weld puddle, making multiple weld layers possible at the joint. GMAW is a relatively simple, versatile, and economical welding apparatus to use. This is due to the factor of two times welding productivity over Shielded Metal Arc Welding (SMAW) processes that is one of the oldest, simplest, and most versatile arc welding processes. The arc is generated by touching the tip of a coated electrode to the workpiece and withdrawing it quickly to an appropriate distance to maintain the arc. In addition, the temperatures involved in GMAW are relatively low and are therefore suitable for thin sheet and sections less than 1/4 inch. GMAW may be easily automated, and lends itself readily to robotic methods. It has virtually replaced SMAW in present-day welding operations in manufacturing plants (Lyndon 2004).

In welding or cutting, the intense heat of the arc or flame vaporizes the base metal and/or the electrode coating. This vaporized metal condenses into tiny particles called fumes. These fume particles can be inhaled. Chromium fume is created by welding or cutting on stainless steel or metals that are coated with a chromium material. Welding on stainless steel without adequate control measures can lead to exposure at least several times above the legal exposure limit. http://www.bls.gov/oco/ocos226.htm

Among the short term effects of welders exposure is metal fume fever, symptoms of which occur 4-12 hours after exposure and include chills, fever, muscle ache, chest soreness, coughing, wheezing, fatigue, nausea, and a metallic taste. Welding fumes can irritate the eyes, nose, chest and respiratory tract and cause coughing , wheezing shortness of breath, bronchitis, pulmonary edema, and pneumonitis. Gastro-intestinal effects such as nausea, appetite loss, vomiting, cramps, and slow digestion also have been associated with welding fumes. Ultra-violet radiation given off by welding reacts with oxygen and nitrogen in the air to form ozone and nitrogen oxides, which are deadly at high doses, irritate the nose and throat, and cause serious lung diseases.

Long term effects include increased risk of lung cancer and possible larynx and urinary tract cancer as welding fumes, contain cancer causing agents such as cadmium, nickel, chromium, beryllium, and arsenic. Welders also may have chronic respiratory problems.

Other health problems that appear to be related to welders include heart diseases, skin diseases, hearing loss, and chronic gastritis. Studies have shown that welders, especially those who work with stainless steel, have poorer sperm quality than men in other works. Other studies reported neurodegenerative diseases that affect mental and physical ability (Vicki 2003).

Glomerular injury has been noted in chromium workers, in chrome platers, and in stainless steel welders. The predominant renal injury is tubular. Low doses chromium exposure typically results only in transient renal effects (Powers et al., 1986).

Increased urinary levels of B2 microglobulin are found in people with kidney damage caused by high exposure to the heavy metals. Periodic testing of workers exposed to these metals helps to detect beginning kidney damage (Henry 1996).

Aim of the work

The aim of the present study was: (1) To investigate some of the health hazards among gas metal arc welders with special emphasis on renal and lung examination. (2) To monitor the level of chromium in blood and urine, and studying its relation with the renal condition.(3) Assessment of B2 microglobulin in urine.

Subjects and methods

This study was conducted in three welding shops in El Manial, and El Maadi, in Cairo. The study was accomplished during the months of October and November 2006.

The studied group comprised 18 workers in the metal arc welding shops. They were adult men aged between 18-42 years (26.5 ±7.8), working on the basis of 12 hours/day with one day off per week. None of the workers used any protective equipment during working hours. A referent group of 20 males matched for age (that ranged from 21-41 yrs., 26.2±6.38), sex, socio-economic status, smoking habits selected from relatives of the Kasr El Eini hospital patients, were also enrolled in our study. The following investigations were performed after taking individual consent:

(A) All workers were interviewed using a special questionnaire including occupational history ; and full clinical examination was performed.

(B) Ventilatory function tests were done using portable spirometer connected to a portable computer using the soft ware ZAN program, measuring FVC (Forced vital capacity), SVC (Slow vital capacity) , FEV1% (Forced expiratory volume in the 1st second), FEV1/FVC %, and PEF (Peak expiratory flow). (C) Beta2 Microglobulin in urine. Random urine sample was used, volume between 1-10 ml, taken in plastic urine container (not acidified). Patients were instructed to empty their bladders then drink a large glass of water and then we collected the urine samples from them within one hour at Kasr El-Eini (Industrial and occupational department). The samples were kept in the refrigerator till transferred to the lab. Significant loss of B2 microglobulin activity may occur in acidic urine (pH <or = 6) , So pH of urine was adjusted to be between (6-8) with 1 mol/L sodium hydroxide. Analysis of B2 microglobulin in urine was done using immuno-chemiluminometric assay (ICMA). Normal range is (0-160) ug/l (Henne et al., 1997). (D) Blood and urine chromium levels.(E) Urea and creatinine and fasting serum sugar level.

Normal blood chromium concentrations are in the range of 10 µg/L to 30 µg/L Chromium rapidly clears from the blood, and measurements relate only to recent exposure (Goyer and Clarkson, 2001). Normal urinary chromium values are typically less than 10 µg/g creatinine (Goyer and Clarkson, 2001).

Blood sample collection

From each subject, 10 cc of blood were taken through a vein puncture using a dry plastic disposable syringe under complete aseptic condition. Three cubic centimeters of blood were taken into a clean tube containing anticoagulant for determination of chromium level in blood. The remaining 7 cc of blood were kept in a tube and allowed to clot then centrifuged for separation of the serum for determination of the following biochemical parameters using Hitashi (911) auto analyzer: i- Kidney function test as urea and creatinine, ii- Random serum sugar level. All Samples were transported to the laboratory on the same day within two hours to be analyzed.

Urine sample collection:

A urine sample was collected from each subject, in a sterile container. All subjects washed their hands with soap and water prior to sample collection to avoid contamination.

Determination of chromium in blood and urine:

The samples for blood chromium level were prepared by dilution of 0.5 ml of blood with 2 ml deionized water. The samples of urine were prepared by dilution of 1 ml of urine with 1ml of deionized water. The chromium in blood and urine were measured by graphite furnace atomic absorption spectrophotometer (Perkin-Elmer model 5100 PC, Norwalk, CT).

1-Sample preparation:

Three per cent butan-1-ol was added to samples and standards to match the carbon content with the aim of ensuring that the ionization efficiency of elements such as chromium is the same in all solution. TAMA 0.1% chemicals (Kwasaki city, Japan) supercleaning, (high purity surfactant), was added to maintain a stable emulsion within the diluted sample. HNO3 0.05% was added to ensure that the trace elements are maintained in solution and to aid wash out of these elements between samples; the acid concentration was kept to a minimum, otherwise cellular component in blood sample in particular will aggregate.

2-Calibration solution preparation:

External calibrator for chromium was prepared by serial dilution of parent stock (1000 μg/ml) using the diluents as those used to dilute and prepare the sample.

3-Optimization of technique:

For reading concentration of both sample and standard (calibrator), first it was important to choose proper wave length, lamp current band pass optimization.

4-Calculation of the results:

By plotting standard curve, the reading of absorbance of sample and calibrator was plotted on semilog curve, the concentration of Cr in sample was interpreted from this standard curve. All investigations were done at The Biochemistry department at The National Research Centre, Dokki.

Results and Discussion

Chromium is a metal which exists in several different forms: divalent, trivalent, and hexavalent. Workers in many different occupations are exposed to hexavalent chromium. Occupational exposures to hexavalent chromium occur mainly among workers who: a) handle dry chromate-containing pigments; b) spray chromate-containing paints and coatings; c) operate chrome plating baths; and d) weld or cut chromium-containing metals such as stainless steel (Cohen and Costa 1998).

Our results showed a statistically significant difference between the exposed and the control groups as regards the spirometric parameters indicating air-ways obstruction such as FEV1/FVC%, PEF%, and MEF 25-75% as shown in (table1), and these results are in accordance with

(Frantzen 1998) who reported that the primary target organ for subchronic and chronic chromium toxicity is the respiratory system as evidenced by various signs and symptoms ranging from irritation of the respiratory tract, obstructive air ways to perforation of nasal septum.

We demonstrated also in our work that there was a statistically significant difference between the exposed and the control groups as regards the levels of chromium in blood and urine even though these levels did not exceed the normal range, but were still higher in the exposed than in the control group. There are no routine medical tests to measure the amount of hexavalent chromium that has been absorbed into the body. Excreted chromium can be measured in urine. However, this test is only useful for measuring recent exposure to stainless steel welding fumes. In most situations, air monitoring gives the best measure of worker exposure (ATSDR, 2000). Huvinen and his colleagues (1996) conducted a cross sectional study to determine whether occupational exposure to hexavalent chromium caused respiratory diseases, decrease in pulmonary functions, or signs of pneumoconiosis in stainless steel production workers and they found that with high level of blood and urine chromium levels there was also a great insult on the pulmonary functions and these results are consistent with our results.

Since uncontrolled diabetes mellitus may lead to proteinuria , we compared between the exposed and control groups as regards the level of fasting blood sugar, and we found no statistically significant difference between both groups as regards the blood sugar level, but we found a statistically significant difference between both groups as regards the level of B2 microglobulin. These results can be explained by the fact that glomerular injury has been noted in chromium workers, but the predominant renal injury is tubular, with low doses acting specifically on the proximal convoluted tubules. Low-dose, chronic chromium exposure typically results only in transient renal effects. Elevated urinary B2-microglobulin levels (an indicator of renal tubular damage) have been found in chrome platers, and higher levels have generally been observed in younger persons exposed to higher Cr (VI) concentrations (Powers et al., 1986). Liu and his colleagues (1993) found a statistically significantly higher urinary B2-microglobulin level in hard-chrome electroplaters exposed to 0.0042 mg chromium/m3 for a mean of 5.8 years and these results are in accordance with our results. We also showed a statistically significant difference between the exposed and the control groups as regards urea and creatinine levels. Verschoor and his colleagues (1988) who compared renal function test results in chrome platers and construction workers revealed that the chrome platers had significantly ($p<0.001$) higher levels of urinary chromium but there was no differences in blood urea , creatinine, or urinary B2-microglobulin . These results do not go with our results and this may be due to the fact that results of the exposed and the control groups in our work which are statistically different are still in the normal range.

Table (1) Comparison between the exposed and control groups as regards different investigations:-

The studied groups / Parameters and normal values	Exposed group N:18		Control group N:20		t test	P value
	Mean	±SD	Mean	±SD		
FVC% of the predicted	78.5	± 5.9	83.9	± 5.9	0.11	> 0.05
SVC% of the predicted	79.83	± 6.2	83.9	± 5.9	0.7	> 0.05
FEV1/FVC	71.83	± 6.2	79.6	± 4.3	4.7	< 0.05
PEF% of the predicted	61.6	± 3.5	72.8	± 4.1	8.8	< 0.001
MEF 25/75% of the predicted	61.1	± 8.3	75.5	± 4.6	6.6	< 0.05
Chromium in blood (Up to 30 ug/L)	13.9	± 2.6	4.8	± 0.7	14.8	< 0.001
Chromium in urine (< 10 ug/g creatinine)	8.6	± 0.58	3.2	± 0.7	24.7	< 0.001
B2 microglobulin in urine (0-160 ug/L)	145.9	± 11.7	52.9	± 18.4	18.2	< 0.001
Urea (10-20 mg/dl)	20.9	± 3.8	16.7	± 1.1	4.6	< 0.05
Creatinine (0.7-1.2 mg/dl)	1.02	± 0.12	0.8	± 6.1	6.6	< 0.05
Fasting blood sugar (80-120 mg/dl)	125.4	± 9.1	117.2	± 14.72	2	> 0.05

Despite the fact that there is no statistically significant difference as regards smoking habit between exposed and controls group ($p>0.05$) (table 2), table (4) shows that the mean values of FVC% of pred., SVC% of pred., and FEV1/FVC among the exposed group are statistically significantly lower than those of the controls ($p<0.05$).

Our study is more or less in consistent with the results of (Shirakawa and Morimoto 1996); the irritant effect of chromium compounds can explain this pulmonary dysfunction.

Table (2) Smoking habit among the examined groups:-

Studied group	Smokers		Non smokers		Total
	N	%	N	%	
Exposed	11	61.1	7	38.9	18
Control	13	65	7	35	20
Total	24		14		38
X^2	0.06				
P value	> 0.05				

Our study demonstrated a statistically significant difference between the exposed and the control groups as regards the occurance of metal fume fever as shown in (table 3). The Agency for Toxic Substances and Disease Registry (ATSDR , 2005) reported that inhaling large amounts of metal or metal oxides (as zinc dust or fumes from smelting or from welding as chromium oxides) can cause a specific short-term disease called metal fume fever, which is generally reversible once exposure to these fumes ceases. The effects of inhalation exposure to chromium compounds vary somewhat with the chemical form of the chromium compound, but the majority of the effects seen will occur within the respiratory tract. The term "metal-fume fever" describes an acute industrial illness characterized by a variety of symptoms, including fever, chills, dyspnea, muscle soreness, nausea and fatigue, which occur in workers following the inhalation of finely dispersed particulate matter formed when certain metals are volatilized. The oxides of a number of metals, including zinc and chromium, can cause this acute, reversible syndrome.

Table (3) Occurance of metal fume fever among the examined group:-

Studied group	Metal fume fever		No metal fume fever		Total
	N	%	N	%	
Exposed	8	44.44	10	55.55	18
Control	0	0	20	100	20
Total	8		30		38
X2	11.2				
P value	< 0.05				

Table (4) demonstrated that there was no statistically significant difference between smokers and non- smokers among the exposed groups as regards blood and urine chromium levels; urea and creatinine levels; B2 microglobulin level and fasting blood sugar level. In agreement with our results Halasova et al., (2005) found that in a group exposed to chromium there was no significant effect of smoking on blood or urine level of chromium. As regards the renal insult due to smoking, our results showed no statistically significant difference between smokers and non- smokers. Similar results were also reported by (Mortada et al., 2004) who measured serum levels of creatinine, B2 microglobulin and blood urea nitrogen (BUN) to assess glomerular filtration among smokers and non smokers and they found that the Cd level in blood and Pb level in blood and hair were significantly higher in the smokers than non-smokers. Blood levels of Cd and Pb correlated significantly with the smoking index (an indicator for the degree of smoking) in the smokers group. The studied markers of kidney damage were neither elevated among the smokers nor correlated with the exposure indices of these metals. They concluded that smokers are exposed to Cd and Pb and this exposure is not high enough in smokers to produce nephrotoxicity.

Our study showed also in (table 4) that there was no significant difference between smokers and non- smokers as regards fasting blood sugar level. In accordance with our work Uchimoto and his colleagues (1999) found that cigarette smoking habit is not a risk factor for Type 2 DM and it has no role in elevating the blood sugar level.

Table (4) Effect of smoking among the exposed group on different investigations:-

The exposed group / Parameters and normal values	Smokers N:11		Non-Smokers N:7		t test	P value
	Mean	±SD	Mean	±SD		
FVC% of the predicted	75.18	± 4.09	83.71	± 4.3	4.1	< 0.05
SVC% of the predicted	76.45	± 4.08	85.14	± 5.4	3.8	< 0.05
FEV1/FVC	70.36	± 4.8	74.42	± 6.2	2.8	< 0.05
PEF% of the predicted	60.72	± 3.4	63.14	± 3.2	1.45	> 0.05
MEF 25/75% of the predicted	60.27	± 7.5	62.57	± 9.9	1.46	> 0.05
Chromium in blood (Up to 30 ug/L)	13.55	± 2	14.5	± 3.4	0.79	> 0.05
Chromium in urine (< 10 ug/g creatinine)	8.6	± 0.48	8.5	± 0.75	0.000	> 0.05
B2 microglobulin in urine (0-160 ug/L)	146.14	± 14.1	145.64	± 7.4	0.086	> 0.05
Urea (10-20 mg/dl)	20.8	± 3.6	21.2	± 4.3	0.18	> 0.05
Creatinine (0.7-1.2 mg/dl)	1.04	± 0.11	1	± 0.14	0.76	> 0.05
Fasting blood sugar (80-120 mg/dl)	124.27	± 7.07	127.28	± 12.24	0.6	> 0.05

From the results of our research we can conclude that there was no statistical significant correlation between the duration of exposure to chromium in welding and results of different investigations done, but these results showed also that the more the exposure duration the more affection of the pulmonary functions even if this relation does not reach the level of significance as shown in (table 5). (Lindberg and Hedenstierna 1983) reported that workers exposed to mean concentrations of 0.002-0.02 mg chromium (VI)/m3 had slight, transient decreases in forced vital capacity (FVC), forced expired volume in 1st second (FEV1), and forced mid-expiratory flow during the workday and workers exposed to <0.002 mg chromium (VI)/m3 showed no effects on lung function and these effects have no relation with the duration of exposure to chromium. Exposure to dusts of chromium salts has been suspected as a cause of asthma, coughing, wheezing, and other forms of respiratory distress in ferrochromium and welders workers. These above results are in accordance with our results. Table 5 shows also that there was no statistical significant correlation between the duration of exposure to chromium and the levels of chromium in blood and urine in the exposed group and this was also reported by Goyer and Clarkson (2001) who found that chromium rapidly clears from the blood, and measurements relate only to recent exposure, and added that urinary chromium excretion reflects absorption over the previous 1 or 2 days only. If sufficient time has elapsed for urinary clearance, a negative bio-monitoring result can occur even with injurious past exposure.

Table 5 reveals no significant correlation between duration of exposure to chromium and renal affection . This may be explained by the affection of the kidney depends on the amount of exposure not the duration. This may be explained also by the limited number of workers here in our study and the variation of the duration of exposure could not be studied well and this could be explained by the fact that chromium has no cumulative effect in the body. In contrast to our findings Muttamara and Leong (2004) demonstrated that blood and urinary levels of chromium among workers were associated with increasing duration of exposure.

Table (5) Correlation coeffiecient between duration of exposure to chromium in welding and results of different investigations:-

Parameters	r	F	P value
FVC%	-425	0.79	> 0.05
SVC%	-0.401	0.09	> 0.05
FEV1/FVC%	-0.09	0.97	> 0.05
PEF%	0.023	0.928	> 0.05
MEF 25-75%	-0.12	0.05	> 0.05
Chromium in blood	0.52	0.02	> 0.05
Chromium in urine	0.03	0.88	> 0.05
B2 microglobulin in urine	0.028	0.24	> 0.05
Urea	0.173	0.49	> 0.05
Creatinine	0.27	0.26	> 0.05

Our study revealed that there was a statistically significant correlation between the level of chromium in blood and its level in urine as shown in (table 6).

Our findings are in agreement with (Shouman et al., 1999), however they didn't agree with (Kornhauser et al., 2002). This could be due to the higher exposure to chromium in our environment than in Kornhauser's study which was carried out in tanning industry.

We found a statistically significant correlation between the level of blood chromium and renal insult represented by the affection of B2 microglobulin, urea, and creatinine.

Powers and his colleagues (1986) reported that glomerular injury has been noted in chromium workers, the predominant renal injury is tubular, with low doses acting specifically on the proximal convoluted tubules and this injury is correlated with the blood chromium level as low-dose, chronic chromium exposure typically results only in transient renal effects. They also reported that elevated urinary B2-microglobulin levels (an indicator of renal tubular damage) have been found in chrome platers, and higher levels have generally been observed in younger persons exposed to higher Cr (VI) concentrations. However , they suggested a urinary threshold for nephrotoxic effects is 15 µg chromium/g Creatinine. Powers and his colleagues' findings are in accordance with our results obtained in (table 6) except for the point that nephrotoxic effects in our study were noticed at urinary chromium levels around 8.6 ± 0.48. This may be explained by the fact that in Egypt , The kidneys are more susceptible to diseases than in other populations due to the endemic urinary Bilharziasis.

Statistically significant correlation between the level of blood chromium and the reduction of FEV1/FVC and MEF25-75% is demonstrated in our work in (table 6). These results are in accordance with the results obtained by Nordberg (1998) who reported that the occurrence of bronchospasm in persons working with chromates suggests chemical irritation of the lungs and this bronchospasm was related to chromium exposure and its level in blood.

Table (6) Correlation coefficient between the levels of chromium in blood and different parameters:-

Parameters	r	F	P value
FEV1/FVC%	-0.488	0.002	<0.05
MEF 25-75%	-0.764	0.00	<0.001
Chromium in urine	0.910	0.00	<0.001
B2 microglobulin in urine	0.867	0.00	<0.001
Urea	0.77	0.00	<0.001
Creatinine	0.671	0.00	<0.05

Recommendations

From the present study we recommend environmental monitoring in different areas in the welding shops to ensure that permissible levels of different hazardous agents are not exceeded. Pre-employment and periodic medical examinations must be performed to exclude those susceptible to lung and renal diseases. Personal protective clothes e.g. gloves and respiratory protective equipment should be used in welders. Health education programs of workers about hazards of exposure to harmful agents and proper measures for protection is essential and this includes training programs to raise awareness among welders. Effective local exhaust ventilation to remove hazardous gases and fumes is essential. Finally, urinary or blood chromium can be used as indicators of recent chromium exposure among welders.

References

1. Agency for Toxic Substances and Disease Registry (ATSDR)(2005): Toxicological Profile for Zinc (Update). Atlanta, GA: U.S. Department of Public Health and Human Services, Public Health Service.

2. ATSDR (2000): Case studies in Environmental Medicine. Chromium toxicity. Course: SS3048.http://www.atsdr.cdc.gov/HEC/CSEM/chromium.

3. Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, 2006-07 Edition, Welding, Soldering, and Brazing Workers, on the Internet at http://www.bls.gov/oco/ocos226.htm.

4. Cohen MD and Costa M (1998): Chromium Compounds, Chapter (74), in: William N Rom ed. Environmental and Occupational Medicine, 3rd edition. Lippincott Raven Publishers, Philadelphia. p. 1045-55.

5. Frantzen K (1998): Chromium, Chapter (12), in: Harbison RD, ed. Hamilton &Hardy´s Industrial Toxicology, 5th ed. New York, London Sydney, Tokyo, Toronto. p. 51-54.

6. Goyer RA and Clarkson TW (2001): Chromium. Toxic Effects of Metals, Chapter (23), in: Klaassen CD, ed. Casarett and Doull´s: The Basic Science of Poisons, 6th edition. McGraw-Hill. New York, London Sydney, Tokyo, Toronto. p. 826-27.

7. Halasova E, Baska T, Kukura F,Mazurova D, Bukovska E, Dobrota D, Poliacek I, and Halasa M (2005): Lung cancer in relation to occupational and environmental chromium exposure and smoking. In Neoplasm; 52 (4):287-91.

8. HenneV , Frei P, and Burgisser P L(1997):- "Beta2-microglobulin. A Rapid and Automated Determination for a Broad Range of Clinical Applications." Anticancer Research: 2915-2918.

9. Huvinen M, Uitti J and Zitting A (1996): Respiratory health of workers exposed to low levels of chromium in stainless steel production. Occup. Environ. Med. 53:741-747.

10. Henry J B (1996):- Clinical diagnosis and management by laborarory methods, 19th ed. Philadilphia:W.B Saunders CO.

11. Kornhauser C, Wrobel K, Malacara JM, Nava LE, Gomez L and Gonzalez R (2002): Possible adverse effects of chromium in occupational exposure of tannery workers. Ind. Health. 40: 207-13.

12. Lindberg E and Vesterberg O (1983): Monitoring exposure to chromic acid in chromeplating by measuring chromium in urine. Scand. J. Environ. Health 9:333-40.

13. Liu CS, Kuo HW and Lai JS (1993): Urinary N-acetyl-B-glucosaminidase as an indicator of renal dysfunction in electroplating workers. Int. Arch. Occup. Environ. Health 71:348-352.

14. Lyndon G S (2004) :Welding and thermal cutting. 3rd edition of the Encyclopaedia of Occupational Health and Safety article .

15. Mortada WI, Sobh MA, and El-Defrawy MM (2004): The exposure of cadmium, lead and mercury from smoking and its impact on renal integrity.In: Med. Sci. Monit. ; 10 (3): CR 112-6. Urology and Nephrology Center, Mansoura University, Mansoura, Egypt.

16. Muttamara S, and Leong ST (2004): Health implication among occupational exposed workers in a chromium alloy factory, Thailand. J. Environ. Sci. (China) ; 16 (2): 181-6.

17. Nordberg G (1998): Chromium. Metals: Chemical properties and toxicity.In: Stellman J Mager ed. Encyclopadedia of Occupational Health and Safety. 4th edition. Vol. (3) International Labour Office. Geneva. p.63.11-14.

18. Powers WJ, Gad SC, Siino KM and Pechman JC (1986): Effects of therapeutic agents on chromium-induced acute nephrotoxicity, in: Serrone DM, ed. Chromium symposium: an update. Pittsburgh (PA): Industrial Health Foundation, Inc. p. 79-86.

19. Shirakawa T and Morimoto K (1996): Brief reversible bronchospasm resulting from bichromate exposure. Arch. Environ. Health 51(3): 221-25.

20. Shouman AE, Abdel Karim AH, Gadallah MA, Al- Ansary MS and Kalil SB (1999): Health hazards among workers of tanning. Egypt. J. Comm. Med. 17 (1):17-23.

21. Uchimoto S, Tsumura K, Hayashi T, Suematsu C, Endo G, Fujii S, and Okada K (1999): Impact of cigarette smoking on the incidence of type 2 diabetes mellitus in middle- aged Japanese men : the Osaka Health Survey . In: Diabet. Med. ; 16 (11):951-5.

22. Verschoor MA, Bragt PC and Herber RF (1988): Renal function of chrome-plating workers and welders. Int. Arch. Occup. Environ. Health 60:67-70.

23. Vicki B (2003): Welding fume health hazards . Journal of Crit. Rev. in Toxicol. , 33 (1) : 61-103.