MEDICAL SCIENCE MONITOR

CLINICAL RESEARCH

e-ISSN 1643-3750
© Med Sci Monit, 2013; 19: 1001-1005
DOI: 10.12659/MSM.889694

Received: 2013.08.20
Accepted: 2013.09.27
Published: 2013.11.15

Elevated red blood cell distribution width and inflammation in printing workers

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABCDEFG 1 Ahmet Celik
ACD 2 Neriman Aydin
ACDG 2 Birgul Ozcirpici
DEF 3 Edibe Saricicek
BCDG 4 Hatice Sezen
BCDG 5 Mehmet Okumus
BCDG 5 Selim Bozkurt
CEG 1 Metin Kilinc

1 Medical Faculty, Medical Biochemistry, Sutcu Imam University, Kahramanmaras, Turkey
2 Department of Public Health, Medical Faculty, Gaziantep University, Gaziantep, Turkey
3 Biochemistry Laboratory, Dr. Ersin Arslan State Hospital, Gaziantep, Turkey
4 Department of Biochemistry, Medical Faculty, Harran University, Harran, Turkey
5 Department of Emergency, Sutcu Imam University, Medical Faculty, Kahramanmaras, Turkey

Corresponding Author: Ahmet Celik, e-mail: drahmetcelik@gmail.com
Source of support: Departmental sources

Background: The aim of this study was to estimate the effects of exposure to chemical compounds on systemic biochemical inflammatory markers in printing industry workers.

Material/Methods: Fifty-eight printing workers from 19 different small- and medium-sized enterprises in the printing sector were investigated. For comparison, 80 healthy workers not subjected to workplace chemicals served as control subjects.

Results: No significant differences were observed between the printing workers and control subjects with respect to age, BMI, waist circumference/hip circumference ratio, smoking, and alcohol consumption. Printing workers had significantly higher serum TNF-alpha levels (11.02±5.34 *vs.* 9.26±3.87 pg/ml, p=0.039), plasma fibrinogen levels (1.74±0.49 *vs.* 1.38±0.5 mg/dl, p=0.012), and red blood cell distribution width (RDW-SD) (49.77±3.09 *vs.* 47.3±2.88 p<0.01) compared to control subjects.

Conclusions: Elevation of RDW, serum TNF-alpha, and plasma fibrinogen levels in printing workers may be due to systemic toxic effects of chemical compounds used in this sector. TNF-alpha is an inflammatory cytokine that has a wide spectrum of biological activities, and fibrinogen plays an important role in pathological processes. Some compounds may be carcinogenic or mutagenic. Better designed workplaces and working conditions will help to reduce the hazardous effects of chemical compounds.

Key words: red blood cell distribution width • tumor necrosis factor-alpha • fibrinogen • printing workers

Full-text PDF: http://www.medscimonit.com/download/index/idArt/889694

1447 2 — 40

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

Background

Printing workers have traditionally high occupational exposure to health hazards [1–4]. There are significant health risks, such as dermatitis, musculoskeletal disorders, occupational asthma, deafness, eye damage, and other problems associated with the use of solvents and other chemical compounds that need to be considered in the printing sector [1].

Cleaning solvents, fixer solutions, deletion fluids, and various inks are used extensively in this sector. They contain corrosive acids (e.g., concentrated nitric and sulfuric acids, hydrofluoric acid), strong alkalis (e.g., concentrated sodium or potassium hydroxide), hydroquinone, reactive acrylates, sodium thiosulphate, dilute formaldehyde solution, dichromates (e.g., ammonium, potassium and sodium dichromates), isopropyl alcohol, methyl ethyl ketone, white spirit, alcohols (e.g., industrial methylated spirits), esters (e.g., ethyl acetate), aromatic hydrocarbons (e.g., toluene, xylene), propanol, isocyanate prepolymers, perchloroethylene, N-vinyl pyrrolidone, chlorinated hydrocarbons (e.g., dichloromethane), and ketones (eg, cyclohexanone). Exposure to such chemicals can have acute or delayed effects. Solvents and other chemical compounds can be taken into the body by breathing them in, passing through the skin, or by eating food touched by contaminated hands. Some compounds may be carcinogenic or mutagenic [1].

Research continues to reveal systemic and local inflammatory effects of these compounds [5–11]. There is no data about the effects of these agents on systemic inflammatory markers in printing workers. This study was designed to determine the systemic effects of exposure to chemicals in printing industry workers.

Material and Methods

Fifty-eight printing workers from 19 small- and medium-sized printing enterprises were investigated (Group I). For comparison, 80 healthy age-matched workers in fields other than printing, not subjected to workplace chemicals, were chosen and served as control subjects (Group II). All of the printing workers and control subjects were men. Patients with acute infection, neoplasia, previous stroke and MI history, thyroid disorders, taking drugs (such as vitamins, anti-inflammatory agents, or antibiotics), and excessive alcohol consumption (drinking more than 3 times per week) were excluded from the study.

Workers and workplaces

Printing workplaces were small and medium enterprises and had no walls between the areas of different processes (e.g., pre-press, etching, engraving, platemaking, printing, cutting, and drilling). All workers were working in the same area. These workplaces generally had 2–4 workers, and 1 had 16. Working duration was 10–12 hours, mainly between 08: 00 and 18: 00 or 20: 00. While working, workers were generally standing and ventilation and climate control were generally not sufficient. None of the printing workers in this study used gloves, glasses, and/or respiratory protective equipment.

Subjects

All subjects gave informed consent and the study protocol was approved by the local ethics committee. All subjects were examined physically. Age, height, weight, hip and waist circumferences, alcohol consumption, and smoking status were recorded. Blood samples were obtained from the ante-cubital veins at the end of the work shift. Samples were promptly centrifuged at 2500 g, at 4°C, for 10 minutes. Serum and plasma samples were aliquoted and saved at –80°C until measurement of TNF-alpha, plasma fibrinogen levels, and other biochemical parameters.

Biochemical analysis

Routine CBC (complete blood count) tests were promptly conducted with Sysmex XT-2000i automated hematology analyser (Sysmex Corporation of America). Plasma fibrinogen levels were measured using the Clauss clotting method (STA-Fibrinogen Diagnostica Stago) with the STA Compact automated coagulation analyzer (Diagnostica Stago, Albio, France). Serum levels of TNF-alpha were determined using a chemiluminescence enzyme immunometric assay (Immulite-One, Immunassay Analyzer; Immulite DPC, Los Angeles CA, USA). Serum glucose, urea, creatinine, total, LDL and HDL cholesterol, triglyceride, ALT, AST, and total and direct bilirubin levels were measured on a Roche Hitachi Modular System (Mannheim, Germany) autoanalyzer with spectrophotometer.

Statistical analysis

Data were analyzed in SPSS Program 15.0 (SPSS Inc, Chicago, IL, USA). For comparison, Student t test, chi-square test, and Mann-Whitney U test were used as appropriate. For correlations, Pearson's and Spearman's correlation tests were used. Statistical significance was assumed when the p-value was less than 0,05. Results are expressed as the mean ±SD and percent.

Results

Demographic, hematological and biochemical data of workers and controls are given in Table 1 and 2. Mean ages of Group I and Group II were 26.0±8.9 years (15–49) and 27.01±6,26 years (15–48), respectively. All workers had been working at least for 1 year in this occupation (mean=11,23±9,05 years).

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

Table 1. Demographic data of printing workers and control subjects

Parameters	Printing workers (n=58)	Control subjects (n=80)	P value
Age (year)	25.72±8.43	27.33±6.60	0.209
BMI (kg/cm^2)	23.89±3.99	25.17±3.93	0.066
Waist circ/hip circ (cm/cm)	0.89±0.08	0.89±0.06	0.998
Alcohol consumption (%)	22.7	16.7	0.652
Smoking (pockets/year)	157.15±176.70	124.32±199.81	0.331
Working duration (year)	11.23±9.05	–	

Table 1 was obtained from independent t test and chi-square test, the difference is significant if p value <0.05. BMI – Body-mass index.

Table 2. Hematological and biochemical data of printing workers and control subjects

Parameters	Printing workers (n=58)	Control subjects (n=80)	P value
WBC (10^3/µL)	6.60±1.27	6.87±1.41	0.298
RBC (10^6/µL)	5.07±0.52	5.22±1.28	0.458
Hemoglobin (g/dl)	14.93±1.07	15.12±1.20	0.377
Hematocrit (%)	44.64±3.72	43.99±3.75	0.354
MCV (fl/cell)	88.73±4.41	85.76±8.43	0.076
RDW-SD	49.77±3.09	47.3±2.88	<0.001
PLT (10^3/µL)	240.08±45.71	224.06±47.65	0.068
MPV (fL)	9.77±1.05	9.46±0.99	0.099
Glucose (mg/dL)	86.59±11.06	88.45±8.69	0.292
Urea (mg/dL)	15.21±7.43	17.94±7.20	0,060
Creatinine (mg/dL)	0.81±0.12	0.85±0.11	0.053
ALT (U/L)	21.69±13.74	25±14.14	0.186
AST (U/L)	20.52±5.78	21.18±5.75	0.508
ALP (U/L)	83.48±31.82	73.07±28.90	0.083
Total Cholesterol (mg/dL)	163.90±29.34	170.88±33.03	0.220
Triglyceride (mg/dL)	137.45±83.67	119.14±64.63	0.169
HDL-C (mg/dL)	37.54±7.80	39.16±7.75	0.242
LDL-C (mg/dL)	99.12±23.05	107±27.51	0.089
Total Bilirubin (mg/dL)	0.80±0.44	0.81±0.33	0.968
Direct Bilirubin (mg/dL)	0.26±0.13	0.27±0.12	0.762
Uric Acid (mg/dL)	5.77±0.94	5.80±1.15	0.851
TNF-alpha (pg/mL)	11.02±5.34	9.26±3.87	0.039
Fibrinogen (g/L)	1.74±0.49	1.38±0.5	0.012

Table 2 was obtained from independent t test, the difference is significant if p value<0.05. ALP – alkaline phosphatase; ALT – alanine aminotransferase; AST – aspartate amino transferase; HDL-C – high-density lipoprotein cholesterol; LDL-C – low-density lipoprotein cholesterol; MCV – mean corpuscular volume; MPV – mean platelet volume; PLT – platelet; RBC – red blood cell; RDW-SD – red cell distribution width-standard deviation; WBC – white blood cell; TNF – tumor necrosis factor.

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

No difference was detected with respect to age, BMI, waist circumference/hip circumference ratios, smoking, and alcohol usage between Group I and Group II (p>0.05) (Table 1). For hematological and biochemical analyses, no difference was determined between groups with respect to WBC and RBC MCV, MPV, PLT, and routine biochemical tests. However, Group I had significantly higher red blood cell distribution width (RDW-SD) values (49.77±3.09 *vs.* 47.3±2,88, p<0,05) (Table 2).

Serum TNF-alpha levels (11.02±5.34 *vs.* 9.26±3.87 pg/ml, p=0.039), and plasma fibrinogen levels (1.74±0.49 *vs.* 1.38±0.5 mg/dl, p=0.012) were compared to Group II.

Discussion

We found that RDW-SD was statistically higher in printing workers than control subjects (p<0.01). This finding may be evaluated as anisocytosis. RDW is a measurement of the size variation, as well as an index of the heterogeneity of the erythrocytes (i.e., anisocytosis). Higher RDW values reflect greater variation in RBC volumes and were found to be related to many diseases in previous studies [12–14].

We found that RBC and WBC were lower and Hb and MCV were higher in Group I, even if differences were not significant. We hypothesize that DNA and cell division might have been affected by exposure to chemicals via cytotoxicity. Studies should be designed to verify this hypothesis. In addition, *in vitro* inhibition of human erythroid colony formation by TNF-alpha was reported [15]. It has been demonstrated that RDW values are associated with inflammatory markers [16]. In our study, printing workers had higher TNF-alpha and RDW-SD. However, there was no correlation between TNF-alpha and RDW in each of groups and in all subjects.

Peng et al. had found that RDW was higher in the workers occupationally exposed to lead than in an unexposed group, and blood lead was weakly positively correlated with RDW [17]. It has been reported that RDW is higher in prehypertensive and hypertensive patients compared with healthy controls [18]. It has been shown that RDW are elevated in cardiovascular disease pulmonary disease, liver disease, stroke, peripheral artery disease, inflammatory bowel disease, colon cancer, and neoplastic metastases to the bone marrow [19–27]. Many studies have identified RDW as a predictor of all-cause and cardiac mortality [28–30].

Kurtoglu et al. have reported that mean RDW values are higher in smokers than in nonsmokers. They identified significant positive correlations between RDW and number of cigarettes smoked per day and between RDW and duration of smoking [31]. When we excluded smokers, RDW was higher in workers than in controls.

In our study, we found higher TNF-alpha levels in printing workers, possibly due to chronic stress arising from toxic exposure to chemicals. TNF-alpha is synthesized in many tissues with proinflammatory properties and it regulates synthesis of acute-phase reactants such as fibrinogen and factor VII [32]. It inhibits anticoagulatory mechanisms and promotes thrombotic processes and therefore plays an important role in pathological processes such as venous thromboses, arteriosclerosis, vasculitis, and heart failure [33, 34]. It has a direct cytotoxic effect, modulates cell growth and differentiation, and plays a role in chronic inflammatory conditions [35].

It has been found that the concentration levels of inflammatory biomarkers and eosinophilic cationic protein level in the lavage of painters were higher than in the control group. It has been reported that inhalation of VOCs (volatile organic compounds) could be responsible for the occurrence of respiratory inflammatory and allergic diseases [36].

In our study, we found fibrinogen was elevated. It is a key dimeric glycoprotein, taking part in the production of acute-phase reactants by the liver. Fibrinogen levels become elevated with tissue inflammation or tissue destruction. High plasma fibrinogen level may underlie many disorders [37–40].

In this study, printing workers had been working for 11 years on average, ranging from 1 to 30 years. When we classified the workers according to their years worked (less than 5 years, 5–10 years, 10–15 years, 15–20 years, and more than 20 years), the non-significant parameters did not gain statistical significance (p>0.05). No statistical correlation between years worked and TNF-alpha, fibrinogen, and RDW-SD was found in our study.

Conclusions

We found systemic effects of chemicals used in the printing sector and an association between TNF-alpha, fibrinogen, and RDW in printing workers. Working in this profession may contribute to the burden of inflammation and many diseases in printing workers. Improved use of personal protective equipment to reduce occupational exposure to toxic chemical may be indicated by this study.

Future studies in large-scale printing workplaces with larger numbers of workers are required to elucidate this issue.

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

References:

1. Anonymous: The printer's guide to health and safety, Health Risks, HSE Books, England, 2002; 45–54
2. Cherry N, Labrèche F, Collins J, Tulandi T: Occupational Exposure to Solvents and Male Infertility. Occup Environ Med, 2001; 58: 635–40
3. Rushton L, Hutchings S, Brown T: The burden of cancer at work: estimation as the first step to prevention. Occup Environ Med, 2008; 65(12): 789–800
4. Rushton L, Bagga S, Bevan R et al: Occupation and cancer in Britain. Br J Cancer, 2010; 102(9): 1428–37
5. Wichmann G, Mühlenberg J, Fischäder G et al: Release of MCP-1 and IL-8 from lung epithelial cells exposed to volatile organic compounds. Toxicol In Vitro, 2005; 19(5): 685–93
6. Halifeoglu I, Canatan H, Ustundag B, Inanc N: Effect of thinner inhalation on lipid peroxidation and some antioxidant enzymes of people working with paint thinner. Cell Biochem Funct, 2000; 18: 263–67
7. Karagözler AA, Mehmet N, Batcioglu K: Effects of long-term solvent exposure on blood cytokine levels and antioxidant enzyme activities in house painters. J Toxicol Environ Health A, 2002; 65: 1237–46
8. Riise T, Moen Be, Kyvik KR: Organic solvents and risk of multiple sclerosis. Epidemiology, 2002; 13: 718–20
9. Pinto D, Cebellos JM, Garcia G et al: Increased cytogenetic damage in outdoor painters. Mutat Res, 2000; 467: 105–11
10. Lehmann I, Röder-Stolinski C, Nieber K, Fischäder G: *In vitro* models for the assessment of inflammatory and immuno-modulatory effects of the volatile organic compound chlorobenzen. Exp Toxicol Pathol, 2008; 60(2–3): 185–93
11. Pariselli F, Sacco MG, Rembges D: An optimized method for *in vitro* exposure of human derived lung cells to volatile chemicals. Exp Toxicol Pathol, 2009; 61(1): 33–39
12. Montagnana M, Cervellin G, Meschi T, Lippi G: The role of red blood cell distribution width in cardiovascular and thrombotic disorders. Clin Chem Lab Med, 2011; 50(4): 635–41
13. Dugdale AE: Predicting iron and folate deficiency anemias from standard blood testing: the mechanism and implications for clinical medicine and public health in developing countries. Theor Biol Med Model, 2006; 3: 34
14. Means RT Jr: Recent developments in the anemia of chronic disease. Curr Hematol Rep, 2003; 2: 116–21
15. Patel KV, Mohanty JG, Kanapuru B et al: Association of the red cell distribution width with red blood cell deformability. Adv Exp Med Biol, 2013; 765: 211–16
16. Lippi G, Targher G, Montagnana M et al: Relation between red blood cell distribution width and inflammatory biomarkers in a large cohort of unselected outpatients. Arch Pathol Lab Med, 2009; 133: 628–32
17. Peng S, Zhang C, Wang C et al: The investigation on the changes of haematological parameters in the occupationally lead exposed workers. Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi, 2002; 20(5): 334–35
18. Tanindi A, Topal FE, Topal F, Celik B: Red cell distribution width in patients with prehypertension and hypertension. Blood Press, 2012; 21(3): 177–81
19. Zorlu A, Bektasoglu G, Guven FM et al: Usefulness of admission red cell distribution width as a predictor of early mortality in patients with acute pulmonary embolism. Am J Cardiol, 2012; 109: 128–34
20. Hampole CV, Mehrotra AK, Thenappan T et al: Usefulness of red cell distribution width as a prognostic marker in pulmonary hypertension. Am J Cardiol, 2009; 104: 868–72
21. Dabbah S, Hammerman H, Markiewicz W, Aronson D: Relation between red cell distribution width and clinical outcomes after acute myocardial infarction. Am J Cardiol, 2010; 105: 312–17
22. Ani C, Ovbiagele B: Elevated red blood cell distribution width predicts mortality in persons with known stroke. J Neurol Sci, 2009; 277: 103–8
23. Ye Z, Smith C, Kullo IJ: Usefulness of red cell distribution width to predict mortality in patients with peripheral artery disease. Am J Cardiol, 2011; 107: 1241–45
24. Milic S, Mikolasevic I, Radic M et al: Clinical utility of red cell distribution width in alcoholic and non-alcoholic liver cirrhosis. Coll Antropol, 2011; 35: 335–38
25. Clarke K, Sagunarthy R, Kansal S: RDW as an additional marker in inflammatory bowel disease/undifferentiated colitis. Dig Dis Sci, 2008; 53: 2521–23
26. Spell DW, Jones DV Jr, Harper WF, David Bessman J: The value of a complete blood count in predicting cancer of the colon. Cancer Detect Prev, 2004; 28: 37–42
27. Ozkalemkas F, Ali R, Ozkocaman V et al: The bone marrow aspirate and biopsy in the diagnosis of unsuspected nonhematologic malignancy: a clinical study of 19 cases. BMC Cancer, 2005; 5: 144
28. Tonelli M, Sacks F, Arnold M et al., for the Cholesterol and Recurrent Events (CARE) Trial Investigators: Relation Between Red Blood Cell Distribution Width and Cardiovascular Event Rate in People With Coronary Disease. Circulation, 2008; 117: 163–68
29. Felker GM, Allen LA, Pocock SJ et al: Red cell distribution width as a novel prognostic marker in heart failure: data from the CHARM Program and the Duke Databank. J Am Coll Cardiol, 2007; 50: 40–47
30. Patel KV, Semba RD, Ferrucci L et al: Red cell distribution width and mortality in older adults: a meta-analysis. J Gerontol A Biol Sci Med Sci, 2010; 65: 258–65
31. Kurtoglu E, Akturk E, Korkmaz H et al: Elevated red blood cell distribution width in healthy smokers. Arch Turk Soc Cardiol, 2013; 41(3): 199–206
32. Clark IA: How TNF was recognized as a key mechanism of disease. Cytokine Growth Factor Rev, 2007; 18(3–4): 335–43
33. Tousoulis D, Davies G, Stefanadis C et al: Inflammatory and thrombotic mechanisms in coronary atherosclerosis. Heart, 2003; 89: 993–97
34. Hamdy NM: Relationship between pro-anti-inflammatory cytokines, T-cell activation and CA 125 in obese patients with heart failure. Med Sci Monit, 2011; 17(3): CR174–79
35. Kollias G, Douni E, Kassiotis G, Kontoyiannis D: The functions of tumour necrosis factor and receptors in models of multi-organ inflammation, rheumatoid arthritis, multiple sclerosis and inflammatory bowel disease. Ann Rheum Dis, 1999; 58(1): 132–39
36. Wang C, Cao Q, Zhang HZ, Jiang RF: Effects of volatile organic compounds inhalation on the inflammation biomarkers in nasal lavage fluids of decoration workers.Wei Sheng Yan Jiu, 2005; 34(1): 55–57
37. Emerging Risk Factors Collaboration, Kaptoge S, Di Angelantonio E, Pennells L et al: C-reactive protein, fibrinogen, and cardiovascular disease prediction. N Engl J Med, 2012; 367(14): 1310–20
38. Mizuno Y, Jacob RF, Mason RP: Inflammation and the development of atherosclerosis. J Atheroscler Thromb, 2011; 18(5): 351–58
39. Ma J, Xu A, Jia C, Liu L et al: Associations of fibrinogen with metabolic syndrome in rural Chinese population. J Atheroscler Thromb, 2010; 17(5): 486–92
40. Grebe MT, Luu B, Sedding D et al: Fibrinogen promotes early atherosclerotic changes of the carotid artery in young, healthy adults. J Atheroscler Thromb, 2010; 17(10): 1003–8

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]