

甲醛接触对工人肺功能的影响

上海医科大学劳动卫生学教研室 蒋学之 张瑞稳 王英 袁家牛

提要 对430名受试者进行了肺功能测定, 主要为FEV_{1.0}、FVC和 FEV_{1.0}/FVC。根据空气中甲醛浓度分为三组: I组(空气中甲醛 0.70±0.24mg/m³)、II组(1.45±1.30mg/m³)、III组(2.97±2.01mg/m³), 另以无毒物接触史者作对照组。多因素分析表明, 接触甲醛高于 1mg/m³可致 FEV_{1.0}和 FEV_{1.0}/FVC下降, 并与接触工龄相关。FEV_{1.0}/FVC 异常率在III组明显增加, 提示接触浓度在 3mg/m³ 对肺功能有较明显影响。

关键词 甲醛 肺功能 多因素分析

甲醛对呼吸道的刺激作用已为许多报道所证实。但对肺功能的影响, 尚无定论^[1-10]。本文报道对不同甲醛接触水平工人的肺功能测定结果, 以期为这方面的研究提供一定科学依据。

对象与方法

一、研究对象

将319名工人按接触水平分为三组。对照组111名, 无任何毒物接触史。分组特征见表1、表2。

二、项目与方法

1. 询问调查: 以统一的调查表询问人口统计学基本资料、疾病史、职业史(毒物接触史)、吸烟史等。

2. 常规体检: 包括身高、体重、内科检查等项目。

3. 肺功能测定: 用9L水封式单筒肺量计测定 FVC、FEV_{1.0}及计算 FEV_{1.0}/FVC。至少重复测定3次。

表1 肺功能测定结果(女性)

因素	对照组	接 触 组			合 计
		I	II	III	
人 数	47	32	26	42	100
身高(cm)	158.60±5.32	158.91±5.23	160.39±3.31	158.21±5.61	159.00±5.01
体重(kg)	54.64±5.83	56.50±7.41	53.19±6.81	52.71±6.25	54.05±6.92
年龄(岁)	36.45±7.58	31.25±8.02	28.12±6.36	31.31±7.88	30.46±7.62
甲醛工龄(年)	0	8.75±7.42	5.96±4.75	8.67±5.34	7.99±6.02
甲醛水平(mg/m ³)	—	0.70±0.24	1.45±1.30	2.97±2.06	
吸烟指数(支/天×年)	0	0.78±4.42	0	0	0.25±2.50
FEV _{1.0} (ml)	2485.5±429.8	2527.8±371.7	2502.2±296.7	2343.4±417.3	2443.7±380.9
FVC(ml)	2956.2±387.3	2859.4±381.9	2759.8±324.6*	2721.2±486.9*	2775.5±417.2*
FEV _{1.0} /FVC(%)	83.97±8.32	88.55±7.65*	90.97±7.37*	86.38±7.09	88.27±7.50**

与对照组比较 * P<0.05 ** P<0.01

表 2 肺功能测定结果(男性)

因素	对照组	接 触 组			合 计
		I	II	III	
人 数	64	70	83	66	219
身高(cm)	171.05±5.90	171.03±4.85	172.63±6.35	170.00±6.31	171.32±5.98
体重(kg)	62.55±8.66	61.60±7.12	62.16±8.62	63.33±7.97	62.33±7.93
年龄(岁)	36.91±10.51	30.34±9.92	27.34±7.30	33.85±9.97	30.26±9.38
甲醛工龄(年)	0	7.93±7.23	6.17±5.19	9.02±7.64	7.59±6.74
甲醛水平(mg/m ³)	—	0.70±0.24	1.45±1.30	2.97±2.06	
吸烟指数(支/天×年)	111.30±202.05	115.17±207.61	90.14±150.87	100.53±169.45	101.27±175.71
FEV _{1.0} (ml)	3421.2±691.5	3706.4±615.8*	3721.2±810.0	3443.8±700.0	3632.9±649.3*
FVC(ml)	4020.7±755.2	4265.0±578.8*	4218.7±666.6	4168.0±664.9	4218.2±637.5
FEV _{1.0} /FVC(%)	85.03±7.29	86.91±8.88	88.53±8.79**	82.42±10.10	86.17±9.54

与对照组比较 *P<0.05 ** P<0.01

4. 全部资料以IBM计算机汇总分析,作单因素分析后,进行多因素逐步回归分析。计算软件为 SPSS/PC(t)(1987)。

结 果

一、肺功能测定结果(表1、表2)

由表1、表2可见,接触组在身高、体重方面与对照组相近,但年龄低于对照组,男性中吸烟指数亦略低于对照组,这对结果可能产生负影响。因此,对测定结果作单因素分析并不能真正阐明甲醛接触与肺功能的关系。必须控制可能的混杂因素后才能作出可靠的结论。

二、肺功能测定结果的逐步回归分析

作逐步回归分析时,选择的变量列于文后附表1。

1. 全部受试者测定结果的分析(表3)结果表明,性别、身高、年龄、吸烟是影响肺功能的主要混杂因素,这与其他学者的报告一致^[6~9]。但接触水平是影响 FEV_{1.0} 的主要因素,FEV_{1.0}/FVC则与甲醛接触工龄呈负相关,这提示甲醛接触对肺功能有影响,并存在一定的接触效应关系。

2. 不同接触水平工人的肺功能测定结果分析

对照组的分析表明,吸烟是影响 FEV_{1.0}/FVC的主要因素。

接触甲醛平均浓度为0.7mg/m³的第I组,接触工龄未引入回归方程。提示在此浓度下的接触与肺功能测定结果无关。第II组(甲醛浓度为1.45mg/m³)、第III组(2.97mg/m³)的分析中,接触工龄与 FEV_{1.0}/FVC呈负相关。提示肺功能影响发生在接触浓度 >1mg/m³。

三、接触-反应关系分析

我们以临床常用的FEV_{1.0}/FVC 83%为界值,作为反应指标,探讨接触-反应关系。结果见表4、表5。

男性III组,异常率高于其它三组。该组年龄构成、吸烟指数均低于对照组,即使不考虑这一负混杂影响,也提示接触接近3mg/m³甲醛使 FEV_{1.0}/FVC明显降低。其它各组未见显著差异。

年龄分层分析结果表明(表5),30岁以上各组,接触组异常率均高于对照组。说明在校正年龄因素后,接触组中III组异常率高于其它三组。表明吸烟与接触似有加强作用。

表 3 肺功能测定逐步回归分析 (n = 430)

肺功能指标	变量	B	SEB	Beta	P
FEV _{1.0}	身高	39.1234	3.8565	0.4027	0.0000
	年龄	-24.2807	2.5884	-0.2857	0.0000
	性别	687.8497	67.5366	0.4116	0.0000
	吸烟	-0.5604	0.1605	-0.1096	0.0005
	接触水平	-47.2778	19.3440	-0.6607	0.0149
	(截距)	-2912.8733	638.9681		0.0000
FVC	身高	41.7007	4.9468	-0.3912	0.0000
	性别	699.4010	72.4140	0.3813	0.0000
	年龄	-14.9652	2.7787	-0.1615	0.0000
	体重	14.1240	3.6983	-0.1383	0.0002
	(截距)	-4073.3308	739.8410		0.0000
	FEV _{1.0} /FVC	年龄	-0.3087	0.0424	-0.3224
吸烟		-0.0143	2.5780 × 10 ⁻³	-0.2549	0.0000
体重		-0.2129	0.0457	-0.2079	0.0000
甲醛工龄		-0.1458	0.0559	-0.1095	0.0094
性别		2.1088	0.8554	0.1147	0.0141
(截距)		109.2288	2.5934		0.0000

MR: FEV_{1.0}: 0.83434 F = 194.26372 P = 0.0
 FVC: 0.82920 F = 233.82423 P = 0.0
 FEV_{1.0}/FVC: 0.60690 F = 49.44627 P = 0.0

表中 B: 回归系数 SEB: 回归系数标准误差 Beta: 标准回归系数 MR: 复数相关数 F: 方差分析F值。

表 4 FEV_{1.0}/FVC年龄组分析

年龄组别	男 性						女 性					
	对 照		接 触		对 照		接 触		对 照		接 触	
	人数	<83%	%	人数	<83%	%	人数	<83%	%	人数	<83%	%
20~	15	3	20.0	137	19	13.9	8	2	25.0	56	5	8.9
30~	24	4	16.7	46	20	43.5*	19	5	26.3	33	13	39.4
40~	14	7	50.0	23	17	73.9*	20	8	40.0	11	6	54.5*
50~	11	7	63.6	13	12	92.3*	—	—	—	—	—	—
合计	64	21	32.8	219	68	31.1	47	15	31.9	100	24	24.0

* P < 0.05

表 5 吸烟对FEV_{1.0}/FVC的影响 (男)

吸烟指数	对 照			I 组			II 组			III 组		
	N	<83%	%	N	<83%	%	N	<83%	%	N	<83%	%
0	32	9	28.1	30	4	13.3	32	4	11.1	28	9	32.1
1~	18	3	16.7	24	4	16.7	34	9	26.5	26	11	42.3*
200~	10	5	50.0	13	7	53.8	10	3	30.0	8	8	100.0*
500~	4	4	100.0	3	3	100.0	3	2	66.7	4	4	100.0
合计	64	21	32.8	70	18	25.7	83	18	21.7	66	32	48.5

* P < 0.05

讨 论

甲醛接触者肺功能研究,国内尚未见报道。国外研究首先见于1975年 Schoenberg 等对65名酚醛树脂生产工人进行肺功能测定的报道。空气中甲醛浓度为 $0.5 \sim 1 \text{mg/m}^3$,有时可高达 $10.6 \sim 16.3 \text{mg/m}^3$,在此环境下工作5年以上者 $\text{FEV}_{1.0}/\text{FVC}$ 明显下降。呼吸道症状,如咳嗽和咳痰明显增加。Gamble 等(1976)亦对酚醛树脂生产工人的肺功能进行了观察⁽⁴⁾。空气中甲醛浓度为 0.06mg/m^3 ,肺功能无改变,作者认为无慢性影响,但急性接触可致小气道通气障碍。Schachter 等(1986)对15名非吸烟健康志愿者观察2ppm(2.4mg/m^3)甲醛(吸入10分钟)对肺功能的急性影响,受试者出现轻度至中度的上呼吸道刺激症状,但无急性或亚急性肺功能改变⁽⁵⁾。Sander 等(1986)报道了 Schachter 等人相似的研究⁽⁶⁾。9名非吸烟健康志愿者,接触3ppm(3.6mg/m^3)甲醛蒸气30分钟, $\text{FEV}_{1.0}$ 下降2% ($P < 0.05$), $\text{FEF}_{25\sim75\%}$ 下降7% ($P < 0.01$),但继续接触至60~180分钟,无肺功能改变。眼、咽喉刺激症状持续存在。Witek 等(1987)报道2ppm甲醛不会对肺功能造成急性影响⁽⁷⁾。但 Alexandersson 等(1982)⁽⁸⁾对家具厂工人(甲醛浓度为 0.45mg/m^3), Kilburn 等(1987)⁽⁹⁾对使用酚醛树脂的工人和组织学习技术员的观察,有肺功能影响,主要是 $\text{FEV}_{1.0}$ 及 $\text{FEF}_{25\sim75\%}$ 的降低,但观察人数均较少。

本文测定319名接触工人,在校正年龄、性别、吸烟等因素后,接触甲醛浓度在 1mg/m^3 以上者肺功能受影响,表现为 $\text{FEV}_{1.0}/\text{FVC}$ 下降,并与接触工龄成正比。以83%为界值,接触工人中Ⅲ组(甲醛浓度相当于现行卫生标准 3mg/m^3)的异常率明显高于对照组,提示有阻塞性肺功能障碍。肺功能测定可作为甲醛接触的伤害指标之一。

附表1 肺功能指标逐步回归分析中的自变量

变量	定量(数量化)指标	变量	定量(变量化)指标
年龄	岁	工种	接触1,非接触0
性别	男1,女0	甲醛接触水平	空气中甲醛平均浓度(mg/m^3)
身高	厘米	甲醛接触工龄	年
体重	千克	吸烟指数	支/天×年

(杨淑仪,李晓忠、曹春华等同志协助现场工作,特此致谢。)

参 考 文 献

1. WHO, Health-hazard Recommended Occupational Exposure Limite (Formaldehyde). Technical Reports Series 1984; 707, 36~72.
2. Bernstein RS, et al. Inhalation exposure to formaldehyde, An Overview of its toxicity, epidemiology, monitoring and Control. Am Ind Hyg Assoc J 1984; 45(11):778~785.
3. Schoenberg JB, et al. Airway disease caused by phenolic (phenol-formaldehyde) resin exposure. Arch Environ Health 1975; 30: 574~577.
4. Gamble JF, et al. Respiratory function and symptoms. An environmental-epidemiological study of rubber workers exposed to a phenol-formaldehyde type resin. Am. Ind. Hyg Assoc J 1976; 39: 499~513.
5. Schachter EN, et al. A study of respiratory effects from exposure to 2 ppm formaldehyde in healthy subjects. Arch Environ Health 1986; 41(4): 229~239.
6. Sauder LR, et al. Acute pulmonary response to formaldehyde exposure in healthy nonsmokers. J Occup Med 1986; 28(6): 420~424.
7. Witek TJ, et al. An evaluation of respiratory effects following exposure to 2 ppm formaldehyde in asthmatics; lung function, symptoms and airway reactivity. Arch Environ Health 1987; 42(4): 230~237.
8. Alexandersson R, et al. Exposure to formaldehyde, effects on pulmonary function. Arch Environ Health 1982; 37(5): 279~284.
9. Kilburn KH, et al. pulmonary and neurobehavioral effects of formaldehyde exposure. Arch Environ Health 1985; 40(5): 254~260.
10. Alexandersson R. Respiratory hazards associated with exposure to formaldehyde and solvent in acid-resing plants. Arch Environ Health 1988; 43(3): 222~227.

Abstracts of Original Articles

Bronchial Provocation Test (BPT) and Immunological Investigation of Individuals with Toluene Diisocyanate (TDI) Asthma

Liu Jingyu, et al

A specific bronchial provocation test and immunologic analyse was evaluated in 18 workers, with bronchial asthma after exposure to TDI. A positive BPT was observed in 77.8% of subjects, of them 7 showed immediate response and 6 late response while 1 dual response. The pulmonary function such as FVC, FEV₁, MMF, PF, \dot{V}_{75} , \dot{V}_{50} , \dot{V}_{25} reduced markedly in individuals with positive BPT. A higher levels of IgA, specific IgE to TDI antigen were detected in 7 and 9 patients respectively, which was consistent with positive BPT.

The results of these experiments indicated that asthma induced by TDI was allergic mechanism which was especially related to IgE-mediated immediate response. As a method of etiological diagnosis, BPT had obviously specificity and practicality.

Key words: occupational asthma toluene diisocyanate specific IgE to antigen bronchial provocation test

An Evaluation on the Effect of Control Measures and Prediction on the Prevalence of Silicosis in a Lead mine

Lou Jiezhi, et al

In this study the life table method was used to investigate the incidence of silicosis and the effect of its prevention and treatment in a periods of thirty years in a lead mine, and to predict the silicosis trend in the future as well. The results indicated that the prevention and treatment of silicosis since 1950 s'

had led to significant outcome. The incidence of silicosis stage rate of progression, complication with tuberculosis and mortality rate all decreased. The results of prediction showed that the old miners over 50 years of age exposed to the dust environment since 1959 were the main potential victims of silicosis. Incidence of silicosis continued to keep at a higher level within 15 years, then it would begin to decrease significantly in 20 years, and finally, it would decrease greatly 25 years later.

Key words: pneumoconiosis silicosis life table method

Effects of Occupational Formaldehyde Exposure on Pulmonary Function

Jiang Xuezhi, et al

Pulmonary function tests, including measurement of forced vital capacity (FVC), (one-second forced expiratory volume (FEV_{1.0}), and the ratio of FEV_{1.0} over FVC (FEV_{1.0}/FVC, %), were administered to 319 formaldehyde-exposure workers and 111 controls. The former was divided into 3 subgroups, based on their exposure levels, including subgroup I (formaldehyde in air, HCHO-A = 0.70 ± 0.24 mg/m³), subgroup II (HCHO-A = 1.45 ± 1.30 mg/m³), and subgroup III (HCHO-A = 2.97 ± 2.01 mg/m³).

Workers exposed to formaldehyde at levels more than 1 mg/m³ of formaldehyde had lower FEV_{1.0}/FVC ratios than those non-exposed. Analysis of stepwise regression indicated that the FEV_{1.0} of exposurer was negatively correlated with exposure level and the FEV_{1.0}/FVC ratios negatively correlated with exposure duration. The abnormality in terms of FEV_{1.0}/FVC ratios (less than 83%) in group III was higher

Bronchial provocation test (BPT) and immunological investigation of individuals with toluene diisocyanate (TDI) asthma (ABSTRACT) Liu Jingyu, et al.....	(1)
An evaluation on the effect of control measures and prediction on the prevalence of silicosis in a lead mine Lou Jiezhi, et al.....	(6)
Effects of occupational formaldehyde exposure on pulmonary function Jiang Xuezhi, et al	(12)
Short-term effects of smoke fired from electric devices in metro on lung function Xu Xixan, et al	(16)
Method of direct analysis on the data of epidemiologic survey of pneumoconiosis by using dBASE III & Lotus-123 microcomputer program Xiao Fang, et al.....	(19)

than that of control, but those in group I and group II were not. The results suggested that the chronic airway obstruction existed among workers exposed to formaldehyde at levels about $3\text{mg}/\text{m}^3$.

Key words: formaldehyde pulmonary-function stepwise regression

Short-term Effects of Smoke Fired from Electric Devices in Metro on Lung Function Xu xixan, et al

The lung function and blood gas analysis of 18 cases exposed to smoke fired from electric devices were measured. The results showed that the percentage of predicted value of VC, FVC, FEV₁/FVC, MMEF, PEF_R/H, V₇₅/H, V₅₀/H, V₂₅/H and Kco was decreased in the exposed group. They had significant difference as compared with control group. The results of lung function tests showed that the large and small airway function as well

as diffuse capacity were impaired. The long-term effects of lung function need follow up.

Key Words: smoke fire lung function blood gas analysis

Method of Direct Analysis on the Data of Epidemiologic Survey of Pneumoconiosis by Using dBASE III & Lotus-123 Microcomputer Program Xiao Fang, et al

A method of analysis by using micro-computer is introduced, the numbers of cases diagnosed as pneumoconiosis in different periods and the numbers of cases died each year as well as different types of pneumoconiosis encountered in the city of Shenyang were analysed by the method of dBASE III program. A method of how to convey the results to Lotus-123 and to print out was also introduced.

Key words: dBASE data base Lotus-123 software pneumoconiosis