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## Toluene Diisocyanate Exposure in a Glove Manufacturing Plant

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Sisira H. Siribaddana; Anula Wijesundera;  
Ravindra Fernando

*Sri Jayawardenapura General Hospital, Nugegoda (SHS, AW);  
National Hospital of Sri Lanka, Colombo (RF), Sri Lanka*

### ABSTRACT

**Case Report:** An accidental exposure due to reuse of containers of toluene diisocyanate to transport nontoxic substances and subsequent occupational toxic exposure caused illness among forty workers in a glove manufacturing plant. Examination and investigation of the patients and factory site inspection were carried out. Toluene diisocyanate-contaminated latex was examined by the infrared spectroscopy. Thirty-two of forty patients had muscle pain and seven had elevated creatine phosphokinase activity. These features have not been reported previously as components of toluene diisocyanate toxicity and their underlying causation remains speculative.

### INTRODUCTION

Accidental poisoning due to inappropriate storage and transport of toxic substances have been reported from developing countries including Sri Lanka.<sup>1</sup> The reuse of containers of toxic substances to store or transport nontoxic substances can cause poisoning. We report such an incident where occupational toxic exposure caused illness among workers in a glove manufacturing plant.

On January 6, 1994, 32 employees of a surgical

glove manufacturing plant in Homagama, an industrial suburb situated about 20 km southeast of Colombo, were admitted to Sri Jayawardenapura General Hospital, situated about 10 km south of Colombo. Most patients presented with headache, burning sensation of the eyes, and muscle pain. All symptoms started and worsened at work. During the next few days, eight more patients were admitted from the same factory. We suspected an occupational cause for these symptoms and decided to investigate.

Correspondence: Dr. Sisira Siribaddana, Princess Alexendria Hospital, Ipswich Road, Woolloongaba, Brisbane, Queensland 4102, Australia. Tel: 61/7-3240-2690; Fax: 61/7-3240-2973; E-mail: siyi@medicine.pa.uq.edu.au

## METHODS

Structured case record forms were prepared and patient data were entered. Spirometry, serum creatinine, urea, transaminases, and full blood count were performed. Creatine phosphokinase (CPK) activity was measured enzymatically by UV method (Randox Laboratories, UK).<sup>2</sup>

Spirometry was performed using Microspiro-628. Since all of these patients were Sinhalese (majority race in Sri Lanka), a regression equation validated by Udupihille was used to calculate the peak expiratory flow rate (PEFR) with confidence interval. Values falling outside the 95% confidence interval were taken as being abnormal.<sup>3</sup>

Site inspection of the factory and observation of the manufacturing process was done by SHS and AW. Chemical analysis of the latex obtained from different stages of the manufacturing process was carried out at the Ceylon Institute of the Scientific and Industrial Research (CISIR) using the infrared spectroscopy method based on the  $N=C=O$  stretching vibration. Residual toluene diisocyanate (TDI) (a mixture of 2,4 TDI and 2,6 TDI) in the latex was extracted with *o*-dichlorobenzene and gas chromatographic determination using a flame ionization detector.<sup>4</sup>

## RESULTS

Forty patients (18 male), 17–41 years of age, were admitted. All were involved in the manufacturing and storing section of the plant. Their symptoms are shown in Table 1. Eleven employees who were in the accounts department and two workers who were on leave were not affected. Although 10 patients had cough and breathlessness only 8 of them had a PEFR below the normal range. Seven patients had elevated CPK levels (Table 1).

At the factory concerned, centrifuged latex is bought from the rubber plantations in barrels. It then undergoes a process of compounding, vulcanizing, antioxidation, and bleaching before thin rubber sheets are produced. These sheets are used to produce surgical gloves. The factory had been in operation for several years and there were no recent changes in the manufacturing process. We inspected the chemicals (ammonia, zinc sulphate, tetramethyl thorium disulfide, bleaches, etc.) used and their

containers and did not find any contamination, recent change in consistency, or signs of decay. On repeat questioning, workers of the factory informed us that the consistency of the latex had changed. It had a different smell and color and drying was delayed. We could not find a reason for this change. The workers pointed out that the barrels used to transport latex from rubber estates were not new. The barrels had previously been used to transport TDI. Despite the warning label and clear instructions not to reuse, these barrels had been washed and used to store and transport latex from the rubber estates. TDI was identified in the latex and considered a possible cause of these symptoms. After restarting the production with freshly transported latex in new barrels, no workers fell ill.

## DISCUSSION

Isocyanates are widely used in the production of plastics, adhesives, polyurethane foam, and insulation fibers. Commercially and toxicologically the TDI is the most important isocyanate. Methylene diphenyl diisocyanate was used at the Bhopal pesticide manufacturing plant and probably caused more than 2000 deaths.<sup>5</sup>

Isocyanates are strong mucous membrane irritants and pulmonary sensitizers. Our patients had mucosal irritation of the gastrointestinal and respiratory tracts, inflammation of the skin, and conjunctival irritation. Neurological symptoms such as euphoria, ataxia, and memory loss were also seen. Elevated CPK and muscle pain were new manifestations suggesting striated muscle involvement in these patients. We could not find previous documentation of this phenomenon in humans or in animal experiments. There is definite evidence of smooth muscle involvement particularly in the airways.<sup>6</sup>

Isocyanates are highly reactive chemicals because they contain the  $N=C=O$  group that combines with other chemicals containing hydrogen atoms. The strong irritative action is due to this reactivity. Causation of asthma and hypersensitivity pneumonitis by isocyanates is uncertain. There is evidence for both pharmacological and immunological mechanisms.<sup>7</sup> Either of these may be responsible for the muscle pain and elevated CPK.

Industrial and environmental watchdogs should prevent the reuse of containers of toxic substances.

**Table 1**  
*Patient Symptoms (Sx)*

Patient	Muscle Pain*	Abdominal Pain and GI Sx	Headache and CNS Sx	Eye Irritation and Related Sx	Respiratory Sx	PEFR (L/min)†‡	CPK (IU/L)‡
1	+	-,afd	+,ca,am,i	+,r,pp,t	-	<b>242 (399-687)</b>	<b>758</b>
2	+	-	+ca,am,i,ed	-,pp	c,s,d,w	<b>393 (420-708)</b>	118
3	+	+,n	+	+,r,ph	c,d	<b>286 (416-704)</b>	96
4	+	+	+	+,r,t,ph,cu	d,s	<b>296 (420-708)</b>	138
5	+	-	+,i	+,pp,ph	-	<b>140 (337-613)</b>	<b>195</b>
6	+	-	+	+	-	<b>245 (268-546)</b>	82
7	+	+,n,v,afd	+	+,t	-	<b>254 (300-578)</b>	80
8	+	+	+	+,pp	-	<b>238 (268-546)</b>	66
9	+	-	+	+,ph	-	370 (282-559)	93
10	+	n	+	+	s	325 (264-541)	49
11	+	n	+	+,r,t	-	480 (454-743)	84
12	+	-	-	+	-	425 (394-682)	142
13	-	+	+	+	-	<b>300 (314-590)</b>	95
14	-	+	+	+,r,t,ph	-	300 (292-560)	56
15	+	-	+	+	c,s	516 (437-725)	<b>228</b>
16	+	n	+	-	-	550 (390-678)	162
17	+	+,n	+	+,r,t,ph	-	528 (399-687)	<b>199</b>
18	+	-	+	-	-	375 (369-657)	115
19	+	n	-	+,r	c	<b>375 (399-687)</b>	61
20	+	+,v	+,ca,i	+,t	d	<b>425 (459-747)</b>	158
21	+	+	+	+,ph	-	525 (429-717)	<b>211</b>
22	-	+	+,i	+,t,ph	d,s,w	478 (416-704)	102
23	+	+	+	-	-	400 (287-564)	75
24	+	+	-	+	-	325 (269-545)	103
25	+	-	+	+	-	369 (283-559)	38
26	-	+	-	+,t	-	361 (251-527)	68
27	+	+	-	-	-	375 (260-536)	81
28	+	-	-	-	-	377 (251-527)	<b>517</b>
29	+	+	+	-,pp	-	356 (287-564)	53
30	+	-	-	-	-	325 (260-536)	65
31	+	+,n	+,i	+,ph	c,s	340 (245-522)	<b>705</b>
32	-	-	+,i,dp	-,r,t,ph	c,s,d,w	510 (452-740)	106
33	+	+,n	-	+,ph	-	506 (452-740)	112
34	+	-	+	-	-	379 (283-559)	93
35	-	-	+	-	-	426 (287-564)	101
36	-	-	+	-	-	501 (416-704)	123
37	+	-	+	+,r,t	-	<b>257 (283-559)</b>	87
38	+	v	+	+,r,t,ph	-	381 (264-541)	93
39	-	-	+	-	-	497 (399-687)	65
40	+	+	+	+,t	-	450 (407-695)	148

\*None had tenderness, twitching, or fasciculations. †95% CI in normal individuals. ‡Abnormal values in bold. n=nausea, v=vomiting, afd=abdominal fullness and distension, i=irritability, ca=cerebellar ataxia, am=anxiety and memory loss, dp=depression, ed=euphoria and delusion, r=redness, pp=periorbital pain, t=tearing, ph=photophobia, cu=corneal ulcer, c=cough, d=dyspnea, s=sputum production, r=running nose, w=wheeze.

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