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Post Exposure Consequences of Methyl Isocyanate Gas Among Inhabitant of Bhopal During and After Bhopal Gas Tragedy

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ABSTRACT

Bhopal gas tragedy of 3rd December 1984 occurred due to the sudden leak of methyl-isocyanate. After decades of the exposure, severe illness, lung ailments, eye problems, stomach ailments still continue to haunt the lives of survivors of the tragedy. Most affected organs after the exposure include eyes, respiratory tract, and skin. Substantial neurological, reproductive, neurobehavioral, psychological effects, immunotoxicity and genotoxicity were also observed. Scientific debates about the causes of the accident, the spectrum of health effects and their toxicology are presented with a view of understanding the toxic substances released in the gas cloud and their roles in the causation of health effects. Using cutting edge technologies studies on ocular, respiratory, reproductive, psychological, genetic, and immunological aspects must be continued if we have to understand the harshness of long-term effects associated with this tragedy. The authors recommend long-term monitoring of the affected area and use of appropriate methods of investigation that include well-designed cohort studies, case-control studies for a rare condition, characterization of personal exposure and accident analysis to determine the possible elements of the gas cloud.

Keywords: *Methyl Isocyanate, Bhopal Gas Tragedy, Health Effects, Industrial Disasters.*

1. INTRODUCTION

Union carbide set up a pesticide formulation plant at the northern part of Bhopal, Madhya Pradesh in the year 1969. Around 1979 this plant started production of a pesticide known as Sevin. For sevin production MIC is required¹. The MIC was usually made available elsewhere from India. This MIC is usually stored in large tanks (one of them was tank 610). Storage tank had a capacity of 60 tons. MIC is stable at low temperature, and the cooling system of tank 610 was not working in 1984. On the night of 3rd December, 1984 MIC came in contact with water which resulted in an exothermic reaction. Eventually, tank 610 got ruptured and about 30 tons of MIC was leaked. About 20,000 people died and around 20,000 people were exposed to MIC.

The maximum death was recorded area near union carbide including Kazi camp, Jayprakash nagar, Railway colony, New Kabbad Khana, Kenchi chola, and sindhi colony. At the beginning eyes and respiratory system is involved followed by involvement of multiple organs among the exposed population^{2,3}.

The present review describes various short term and long term effects on human organs by exposure of MIC

2. PULMONARY AND RESPIRATORY EFFECTS

Clinical signs and symptoms of MIC exposure were a cough with frothy expectoration, asphyxia, dryness of throat, rhinorrhea, chest pain, and rhinorrhea⁴.

Autopsy studies revealed congestion, oedema, and haemorrhage in lungs along with cherry red blood colour, tenacious material with in the trachea and bronchi.

There was a gross increase in the weight of the lungs, nearly 3 times that of the normal.

In a study conducted by Kamat et al. in MIC exposed inhabitant of Bhopal or Mumbai visitors he noticed that initial symptoms such as a cough, chest pain, and dyspnea etc⁵ were enhanced during the second year of exposure. The spirometric analysis also showed abnormal findings. 25%-75% Forced Expiratory Flow (FEF) of Forced Vital Capacity (FVC) decline progressively during the second year. FVC declines 6-8 months post exposure.

Lung Biopsies performed by Dr. Daebari showed features of bronchiolitis obliterans. Inflammatory exudates surround over the lung parenchyma. Alveolar septae showed thickening and interstitial fibrosis. Macrophages were primarily present in the alveolar lumen. Moreover, terminal bronchioles showed the presence of exudate, as well as inflammation and arterial walls, were thickened suggestive of an obvious reason for pulmonary hypertension^{4, 5, 6}.

3. OCULAR PROBLEMS

Post exposure studies conducted between 8-60 days revealed severe corneal burning, watering, pain, and photophobia due to irritant action of the MIC. The irritant effects even persist after two year post exposure. Apart from above symptoms lid swelling, vascular engorgement, chemosis, punctate keratopathy, Stromal opacification, and iritis were also reported in various studies⁷.

4. PSYCHOLOGICAL AND NEUROLOGICAL PROBLEMS

Tragedy survivors had suffered many psychological issues such as post-traumatic stress disorders, pathological grief reactions, and exacerbation of preexisting problems.

Post-traumatic stress consists of recall of tragic incidence, anxiety, sleep disturbances etc. In a psychiatric outpatient service program set up specifically for the gas victims, Sethi et al.⁹ detected 208 persons suffering from mental problems. Of these, 45% were suffering from neuroses, 35% from anxiety states, and 9% from adjustment reactions. Other psychological problems such as apprehensiveness, jitteriness, depression, and verbosity, in some children above 7 years of age were noticed by Irani and Mahashur. Impairment of auditory and visual memory, attention response speed, and vigilance were also noticed. Learning and motor speed and precision were significantly impaired among affected victims^{8, 9}.

5. REPRODUCTIVE EFFECTS

This disaster has affected the reproductive health of woman severely. Menstrual abnormalities, vaginal discharge, and premature menopause have emerged as common problems among MIC exposed women and their daughters after decades.

A high incidence of spontaneous miscarriages in the pregnant women exposed to the toxic gas was reported. The rate of stillbirth, congenital malformations, perinatal and neonatal mortalities was significantly higher in the affected area. The ICMR has also reported high miscarriage rates in addition to the increased menstrual irregularities and excessive bleeding as a result of postdisaster consequence^{10, 11, 12}.

6. CARCINOGENICITY

A number of studies showed the carcinogenic potential of the MIC. Cancer registry in Bhopal showed relative risk for cancer of 1.4, 1.3. and 0.7 for lung, oropharynx, and buccal cavity respectively. As per as ICMR report higher incidences of cancer were found in the exposed area of Bhopal. A study conducted at Jawaharlal Nehru Cancer Hospital and Research Centre, Bhopal also demonstrated an increase in the incidence of cancer in the exposed population. Although MIC is not classified as a carcinogen by International Agency for Research in Cancer (IARC) and US-Environment Protection Agency (US-EPA)¹³.

Various invitro studies suggested that MIC alters DNA as well as chromosomes which in turns may be responsible for it's carcinogenic potential. MIC leads to bio transformation of several biomolecules. MIC is also a cytotoxic agent as it forms crosslink with DNA¹³.

7. IMMUNOTOXIC EFFECTS

Tucker and coworkers conducted several immunotoxicity studies and reported minor deficits in T-cell lymphoproliferative response and more susceptibility to influenza challenge in MIC-exposed mice¹³. The post exposure analysis had presented increased T cells and TH cell population and normal range of B cells and CD8, 4-8 weeks post exposure¹⁴.

There was a decrease in phagocytosis. Cell mediated immunity was suppressed as indicated by the presence of T-cell rosettes after 10 weeks. The response of T cell and B cell mitogens were also reduced. Low titers of IgG, IgM and IgE class of antibodies were noticed in 11% of the exposed cases¹⁵.

Lung damage is mainly caused by MIC-specific antibodies. In animal models, there is increased phagocytosis of erythrocytes as shown by the increased weight of liver and thymus and impaired alveolar and peritoneal macrophage functions¹⁴.

8. CHROMOSOME ABERRATIONS (CA)

Chromosome aberrations (CA) and sister chromatid exchanges (SCEs) were higher in MIC-exposed individuals compared to controls as reported by Goswami¹⁶. SCE frequencies were tripled in MIC exposed persons in that study. Chromosomal breaks have been observed in 10 out of 14 MIC-affected people (71.4%) studied while only 6 out of 28 (21.4%) controls had chromosomal breaks. Some MIC exposed persons had chromatin bodies in addition to the normal 46 chromosomes. These observations suggest that chromosomal DNA has been damaged. A significant degree of chromosomal aberrations was reported two and half months post disaster, however, no increase in chromosome aberrations was reported by other studies¹⁶.

Chromosomal aberrations was also reported by Deo et al¹⁷. Ghosh et al.¹⁸ assessed frequencies of CA, SCE, and replicative index following peripheral blood lymphocyte culture. CA was recorded in first cycle metaphases (M1) and SCEs at second mitotic cycle (M2), following standard phytohemagglutinin (PHA)-stimulated blood culture protocol. CA frequency was higher in exposed individual predominantly in females. Nondisjunction of chromosomes was also seen resulting absence of aneuploidy. S-phase of cell cycle is mainly affected by MIC which in turn results in circulation of damaged T-lymphocytes for longer period and if the cells are stimulated to divide it results in CA. Such findings on CA suggest that the future generations of the survivors might possibly carry the leftovers of the industrial toxins. Studies suggests that MIC can establish some genetic effect on T-cell precursors¹⁴.

9. CONCLUSION

Bhopal gas tragedy is one of the most detrimental industrial disaster so far documented in the history of mankind. Not only habitant of Bhopal had lost their life but also the people who survived had to carry a number of diseases along with them throughout their life. Primary complains of the patients after exposure to MIC were include burning in eyes as well as breathlessness. A part from ocular and pulmonary symptoms primarily People also suffered genotoxicity, chromosomal abrasion. MIC exposure had also adversely affects reproductive health of female offspring of pregnant women. Due to genetic abnormality the adverse effects of MIC is transferred to next generations. It has also affected patients psychologically. Patients were also suffered from stress, depression etc. We should learn from such industrial disaster and more precautions should be taken during establishment of such plants.

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