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Ophthalmology

COMPARATIVE EVALUATION OF DELAYED OCULAR MORBIDITY IN TOXIC GAS EXPOSED POPULATION WITH NON EXPOSED POPULATION AT BHOPAL

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ABSTRACT

Background: The unprecedented mortality and morbidity due to Bhopal gas tragedy demanded the need for long term monitoring of toxic gas exposed population and use of appropriate methods of investigation for characterization of personal exposure and accident analysis to determine the possible elements of the toxic gas exposure.

Method: Case control study to evaluate and compare ocular morbidity in toxic gas exposed and non exposed population

Conclusion: As compared to previous studies there is increase in incidence of cataract in both case and control group which can be attributed to more number of inmates in older age group and decreased incidence of ocular surface disorder can be attributed to better living conditions, awareness, betters sanitation and better provision of health services. Increased incidence of hypertensive and diabetic retinopathy in case group as compared to previous studies correspond to long duration of systemic diseases and increase life expectancy of individuals.

KEYWORDS : Methyl isocyanate, diminution of vision, corneal opacity, lenticular opacity.

INTRODUCTION:

The leakage of the deadly 30-40 tons of toxic gases from the storage tank of the Union Carbide of India (Limited) factory at Bhopal on the night of December 2-3, 1984 had spread over approximately 30 square miles, killed thousands of people and injured hundreds of thousands. A large number of the inhabitants in the township of Bhopal were exposed to different degrees, depending on their proximity to the plant and atmospheric factors; in fact there are more than 500 000 registered survivors of the tragedy. [1,2,3]

The gas cloud was composed mainly of methyl isocyanate (MIC), apart from it other gases such as phosgene, hydrogen cyanide, carbon monoxide, hydrogen chloride, nitrous oxide, monomethyl amine and carbon dioxide either produced in the storage tank or in the atmosphere was present. All these except carbon dioxide were toxic at levels below 500 ppm. [4]

MIC is clear, colorless, lacrymatory, sharp smelling organic compound which is soluble in water. It is highly toxic and irritating material which is hazardous to human health. [5][6]

The threshold limit value set by American Conference on Government Industrial Hygienist was 0.02ppm. MIC can damage by inhalation, ingestion and contact in quantities as low as 0.4ppm. MIC is potent lachrymator at 2-4ppm; at 21 ppm subjects could not tolerate its presence. [7]

Union Carbide Pesticide Plant in Bhopal used to produce Sevin (trade brand name of carbaryl) using MIC as an intermediate. [8]

ICMR estimated that out of total 832094 population of Bhopal, 521262 suffered from inhalational and exposure toxicity while 311642 escaped the effect of toxic gases. The first official death toll within 72 hrs was 2259. At this nation was shocked facing unprecedented health problems of a totally new disease as nothing was known about its pathogenesis, prognosis and treatment which demanded intensive research into population based long term epidemiological studies [3]

Long term follow up study was done by ICMR in 2 phases on gas victims:

Phase I: March 1985 to August 1988
Phase II: September 1988 to September 1992

Follow up study on delayed ocular effects in exposed population done by Dr S.B.Gupta & Dr Ahluwalia from June 2001 to November 2002 under ICMR. [9]

Present study was carried out from March 2009 to December 2010 on persons who were randomly selected from ICMR baseline cohort registered from severely exposed areas.

Out of 521262 inmates exposed to MIC 80021 inmates were registered for medical research. 4946 persons examined in phase II study by ICMR. Out of these 4946 persons 200 persons from severely exposed area were randomly selected from ICMR cohort.

METHODOLOGY

Study design: Case control study
Duration: March 2009 – 30th December 2010
Study place: Department of Ophthalmology GMC

200 cases and 200 controls were selected by cluster random sampling from ICMR baseline cohort registered from severely exposed and non exposed areas respectively for long term epidemiological study.

These subjects were identified with the help of ICMR field worker by door to door survey and their preliminary examination was done at field with the help of torch, loupe and ophthalmoscope by the doctor. All subjects were referred to Department of Ophthalmology GMC Bhopal where detailed examination was done which includes refraction, slit lamp examination, fundus examination under mydriasis. In relevant subjects' tonometry, syringing, corneal sensation, schrimer test, TBUT, flourescein stain was done. After collection of data, analysis of data was done. Test of significance was applied to selective parameters by chi square test using standard method for statistical analysis.

TABLE 1: MORBIDITY PROFILE DURING MIC EXPOSURE

01	Population of in 1984	832904
02	Total no of inmates in exposed area	521262
03	Total no of affected population	521262
04	Population registered for medical research out of total exposed	80021
05	Population selected for Phase II study	4946
06	Population provided for present study	200

RESULTS:

The population of Bhopal at the time of Bhopal gas tragedy in 1984 was 832904. Out of 521262 inmates exposed 80021 inmates were registered for medical research. 4946 persons were examined in Phase II study done by ICMR [TABLE 1].

TABLE 3: AGE DISTRIBUTION

S.No.	Age group (years)	% of Cases present study	% of Cases previous study 2001-02	% of Control present study
1	0-10	-	0	-
2	11-20	-	10	-

3	21-40	41	26	57
4	41-60	41	40	29.5
5	61-80	16.5	24	13.5
6	>80	1.5	-	-
Total	100	100	100	

400 cases were examined 200 from severely exposed population and 200 from non exposed population respectively by door to door survey and detailed examination in department of ophthalmology.

Out of 200 cases from case and control group respectively females were more in case group and males in control group [TABLE 2].

Most common age group in case group was 21-40 & 41-50yrs and in control group 21-40yrs. There was more number of inmates in older age group in case group as compare to the control group [TABLE 3, Figure 1].

TABLE 2: SEX DISTRIBUTION

S.No.	Sex	Cases present study		Cases previous study 2001-02	Control present study	
		No	%	%	No	%
1	Male	87	43.5	45.8	115	57.5
2	Female	113	56.5	54.2	85	42.5
Total		200	100	100	200	100

Figure 1: AGE DISTRIBUTION

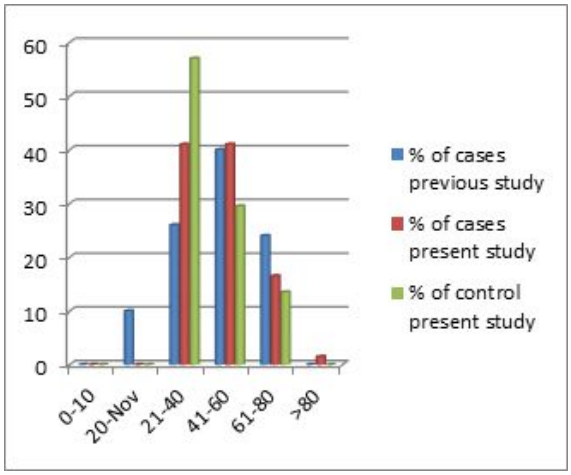


TABLE 4: OCULAR COMPLAINTS

S.No.	Ocular complaints	Cases present study		Cases previous studies		Control present study	
				2001-02	Phase II		
		No	%	%	%	No	%
1	Burning sensation	24	12	26.2	76.0	9	4.5
2	Diminution of vision	115	57.5	43.7	28.0	119	59.5
3	Watering	17	8.5	25.0	68.0	17	8.5
4	Itching	24	12	18.5	58.8	20	10
5	Eyestrain	27	13.5	9.0	16.0	14	7
6	Redness	33	1.65	18.0	50.0	43	21.5
7	F.B. sensations	10	5	10.2	34.2	10	5
8	Dryness	1	0.5	9.0	15.0	-	-
9	Swelling of eyes	2	1	-	-	4	2
10	Headache	18	9	-	-	9	4.5
11	Discharge	23	11.5	-	-	76	38
14	Deviation	1	0.5	-	-	1	0.5
15	No complaints	37	18.5	-	-	56	28

The diminution of vision was the most prominent symptom in both study and control groups. This was due to increase incidence of refractive error and cataract in patients in both case and control group [TABLE 4].

The main ocular findings in both case and control group was refractive error and cataract. There was increase incidence of pterygium, pinguecula and meibomianitis in both case and control group as compare to previous study. There was a decrease in incidence in cases of trachoma in case group and no patient with trachoma was found in control group. No patient with conjunctival xerosis was found in both case and control group. Increase in the nutritional status of the individuals [TABLE 5]

TABLE 5: OCULAR FINDINGS

S.No.	Ocular finding	% of Cases present study	% of Cases 2001-02	% of Control present study	% of Control 2001-02 study
1	Refractive error	30	18.0	28.5	16.2
2	Meibomianitis	6.5	3.8	4	1.0
3	Senile ectropion	3.5	-	1	-
4	Blepharitis	1	-	-	-
5	Blepharochalasis	0.5	-	-	-
6	Degenerative diseases of conjunctiva	8.5	4.5	5.0	1.90
7	Hardeolum internum/ externum	-	-	1.5	-
8	Conjunctival xerosis	-	1.2	-	0.80
9	Conjunctivitis	15	-	26	-
10	Trachoma	0.5	2.4	-	3.2
11	Corneal opacity	5	1.9	3	0.30
12	Lenticular opacity	38	11	29	7.02
13	Corneal dystrophy	1	-	-	-
14	Pseudophakia	7	4	4	2
15	Aphakia	0.5	6	-	-
16	Dry eye	1	-	-	-
17	Squint	3	-	4	-
18	Convergence insufficiency	2	-	2.5	-
19	Retina and optic nerve changes	7.5	4	8	1.50
20	Amblyopia	1	-	0.50	-
21	Chronic dacrocystitis--	-	-	1	-
22	NAD	8	-	14	-

Maximum number of individuals in case and control group had visual acuity in both right and left eye between 6/6 - 6/12, followed by 6/18 - 6/24, 6/36 -6/60, < 6/60 in both eye in both case and control group. No individual in case group was having vision

TABLE 6: VISUAL ACUITY

S.No.	Visual acuity	Cases present study				Cases previous study 2001-02		Control Present study			
		Right eye		Left eye		Right eye	Left eye	Right eye		Left eye	
		No.	%	No.	%	No.	%	No.	%	No	%
1	6/6 - 6/12	168	84	172	86	66.3	65.2	158	79	163	81.5
2	6/18 -6/24	22	11	13	6.5	23.2	19.3	17	8.5	16	8
3	6/36 -6/60	8	4	11	5.5	6.0	9.5	10	5	11	5.5
4	< 6/60	2	1	4	2	4.4	4.0	12	6	10	5
5	HM + PR *	-	-	-	-	0.1	1.5	4	2	1	0.5
6	No. PL	-	-	-	-	-	0.5				
Total		200	100	200	100						

HM+ PR+ as compared to control group where 5 persons were having it. No individual both from study and control group was having No PL. During previous survey in 2001-02 similar pattern of visual acuity distribution among exposed population was seen except that individuals with HM+ PR+ & PL + were also seen at that time [TABLE 6].

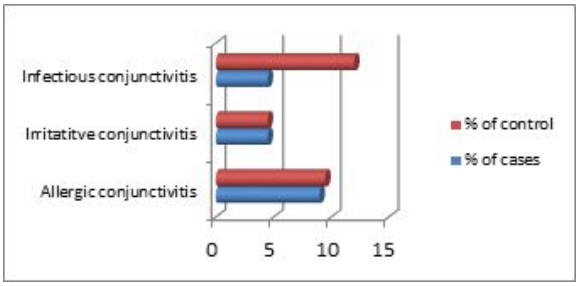
Incidence of infectious conjunctivitis was more in control group as compare to case group [TABLE 7, Figure 4].

TABLE 7: TYPE OF CONJUNCTIVITIS

S.No	Type of conjunctivitis	% of cases	% of control
1	Allergic conjunctivitis	9.0	9.5

2	Irritative conjunctivitis	4.5	4.5
3	Infectious conjunctivitis	4.5	12
Total		18	26

Figure 2: Type of conjunctivitis

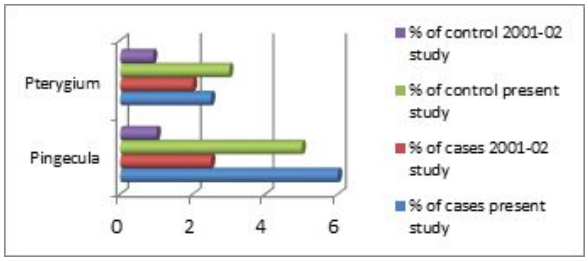


In the case group 8.5% and in control group 8.0% were found to have degenerative diseases of conjunctiva. In 2001-02 study in case group 5.5% and in control group 1.90% were having degenerative diseases of conjunctiva. [TABLE 8, Figure 3]

TABLE 8: DEGENERATIVE DISEASES OF CONJUNCTIVA

S.No.	Degenerative diseases of conjunctiva	% of Cases present study	% of Cases 2001-02 study	% of Cases Phase II study	% of Control present study	% of Control 2001-02 study
1	Pinguecula	6.0	2.5	-	5.0	1.0
2	Pterygium	2.5	2.0	1.63	3.0	0.90
Total	8.5	5.5	1.63	8.0	1.90	

Figure 3: Degenerative diseases of conjunctiva

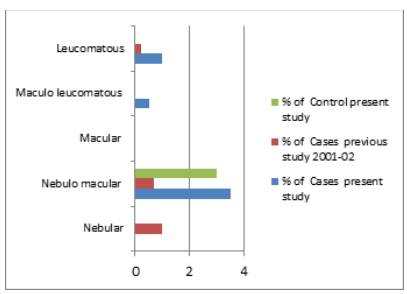


In both groups nebulomacular opacity was the most common opacity, most of them were in the interpalpebral area and was stationary [TABLE 9, Figure 4]. Corneal sensation was reduced only over the corneal opacities in both case and control group. Schrimer test strip wetting <5mm and TBUT <10 sec was found only in 2 patients who were diagnosed case of rheumatoid arthritis in case group.

TABLE 9: TYPE OF CORNEAL OPACITY

S.No.	Type of corneal opacity	% of Cases present study	% of Cases previous study 2001-02	% of Control present study
1	Nebular	-	1.0	-
2	Nebulo macular	3.5	0.7	3.0
3	Macular	-	-	-
4	Maculo leucomatous	0.5	-	-
3	Leucomatous	1.0	0.2	-
Total		5.0	1.9	3.0

Figure 4: Type of corneal opacity



Incidence of lenticular opacity was found increase in both case and control group as compare to previous study and also higher than national incidence with nuclear scelerosis as most common type of cataract and there was presence of lenticular opacity in 100% cases in age >70yr of age. Pseudophakia was more in case group as compare to control group and aphakia is present in only 1 patient in case group [TABLE 10]. Incidence of exophoria with convergence insufficiency was more in case group as compare to control group, no cases with exophoria was reported in previous study [TABLE 11]

TABLE 10: STATUS OF CRYSTALLINE LENS

S. No.	Status of crystalline lens	% of Cases	% of Control
1	Transparent lens	54.5	67
2	Cataractous	38	29
3	Peudophakic	7.0	4.0
4	Aphakic	0.5	-

TABLE 11: TYPE OF SQUINT

S No	Type of squint	% of Cases	% of Control
2	Esophoria	-	-
3	Exotropia	2.5	0.50
4	Esotropia	-	-
Total		9.0	4.0

Fundus was normal in 184 cases (92%) and abnormal in 16 cases (8%) in both case and control group. In case group out of 22 patients who were documented case of hypertension only 4 patients had hypertensive changes in fundus and out of 8 cases with documented diabetes mellitus only 2 patients had diabetic retinopathy. In control group out of 16 patients who were documented cases of hypertension only 2 patients had hypertensive changes in fundus and out of 6 cases with documented diabetes mellitus only 2 patients showed diabetic retinopathy. 4 patients in case group and 2 in control group showed age related macular degeneration and all were above 50 yrs of age [TABLE 12].

TABLE 12: RETINAL / OPTIC NERVE CHANGES

S.No.	Fundus Changes	Case(Toxic gas affected cases)				Control	
		Present study	Previous study 2001-02			No.	%
		No	%	No	%		
1	Hypertensive changes	4	2.0	5	0.5	3	1.5
2	Diabetic retinopathy	2	1.0	6	0.6	2	1.0
3	Macular scar	2	0.5	-	-	-	-
4	Age related macular degeneration	4	2	4	0.4	2	1.0
5	Drusen	3	1.5	-	-	8	4.0
6	Optic atrophy	1	0.50	4	0.4	-	-
7	Myopic chorioretinal degeneration	-	-	8	0.8	-	-
8	Pigmentary degeneration of macula	-	-	12	1.2	-	-
9	BRVO	-	-	-	-	1	0.5

Discussion

Out of 400 patients from case and control group, females were more in case group and males in control group respectively. Most common age group in case group was 21-40 & 41-50yrs (41%) and in control group 21-40yrs (57%). There were more number of inmates in older age group in case group as compare to the control group.

The ocular complaints were asked from the patients and at times leading questions were asked pertaining to the disease suspected, diminution of vision was the most prominent symptom found in both case and control group. Burning sensation was only present in 12% of patient in case group and 4.5% patient in control group. Burning sensation is the most prominent symptom in gas affected population as survey done by Anderson et al in 1984 and study done by ICMR in 1987. Prem Chandra Dwivedi, MS; Jay Krishna Raizada, MS, DO; Vijay Kumar Saini, MS; Prem Chand Mittal, MS 1985 found 100% of exposed patient examined complained of severe ocular burning. [10,11] It

indicates shift of symptoms from the study done in 1984, 1985 & 1987 in exposed population.

The most common ocular finding was found to be lenticular opacity (38%) followed by refractive error (30%) in cases in study group where as in control group both lenticular opacity (28.5%) & refractive error (28.5%) was the most common ocular finding. In Phase II study, 16.2% patient had refractive error, 15.1% had corneal opacity, and 13.9% had trachoma and lenticular opacity in 6.1% cases. Survey 2002 showed refractive error in 18%, lenticular opacity in 11%, trachoma in 2.4%, and corneal opacity in 1.9% case. [9]

Diminution of vision was the most common complaint in both study and control group this is due to increase incidence of patients with refractive error, cataract and patient developing presbyopia. Increase incidence of cataract is due to increase number of patient in present study in older age group and increase incidence of age related cataractous changes. There was an increase in incidence of refractive error and cataract in both study and control group in present study as compare to Phase II study. There was a significant reduction in the incidence of trachoma in present study as compare to study done in Phase II study. [3]This might be due to increase survival of patients in case group due to better health services provided to the gas victims.

Maximum numbers of individuals in study and control group have visual acuity in both right and left eye between 6/6 - 6/12. No individuals in study group were having vision HM+ PR+ as compared to control group where 5 persons are having it due to mature cataract.

In study group 18% of cases of conjunctivitis were found as compare to control group where it was 26%. The cases of infectious conjunctivitis were higher in control group this might be due to poor hygienic condition and poor living standard of patients in control group. There was a decrease in incidence in cases of trachoma in case group and no patients with trachoma were found in control group. This is due to increase awareness of patients and better availability of health services than past. The incidence of degenerative diseases of conjunctiva (including pingecula and pterygium) was 8.5% in study group and 8.0% in control group. This incidence is higher than the previous study done in 1987 (1.63%) and in 2002 (5.5%). [3, 9] This is due to more involvement of individuals in outdoor activities and increase exposure to dust and sunlight.

In present study corneal opacity was found in 5% cases in study group and 3% in control group which is higher than the national incidence (0.73%). This is due to poor visual hygienic, living condition and outdoor work. Nebulomacular opacity was the most common opacity in both case and control group, most of them were in the interpalpebral area. Statistical analysis done by chi square test showed no significant difference between two groups. Corneal sensation was reduced only over the corneal opacities in both case and control group.

Schrimer test was done in all 200 cases in study group and only 50 relevant cases having complaints pertaining to dry eye in control group. TBUT was done in 20 relevant cases each from study and control group having complaints pertaining to dry eye. Only 2 patients who were documented cases of rheumatoid arthritis have schrimer test strip wetting between 5-10mm and also TBUT <10 sec from case group.

In study group 38 % of cases were having lenticular opacity, 29% of cases from control group having lenticular opacity. This incidence is higher in case group then the previous survey done in 2002 and Phase II study which was 11% and 6.1% respectively & was also higher then national incidence of cataract which was 14.2% .[3,9] This was due to increase number of patient in senile age group and non inclusion of younger persons in study. Statistical analysis shows no significant difference between incidence of cataract in case and control group as calculated by chi square test. Incidence of lenticular opacity in both case and control group was higher than national incidence. Nuclear scelerosis was most common type of cataract and there was presence of lenticular opacity in 100% cases in age >70yr of age. Increase incidence of cataract is due to increase number of patient in present study in older age group and increase incidence of age related cataractous changes.

The most common type of cataract was nuclear scelerosis in both case and control group followed by cortical cataract and posterior subcapsular cataract. In case group 5 patients were having mature cataract and in control group 8 patients it corresponds with Framingham Eye Study from 1973-1975, done on 2477 patients found 3 main types of senile cataract — nuclear, cortical, and posterior subcapsular, nuclear, cortical, and posterior subcapsular cataracts were found in 65.5%, 27.7%, and 19.7% of the study population with cataract. Nuclear opacities were the most commonly seen lens change.

Mature cataract was found in 5 patients in study group and 8 patients in control group. Pseudophakia was present in 14 patients in study group out of which 7 patients were having bilateral pseudophakia. In control group 8 patients were pseudophakic and only 1 having bilateral pseudophakia. This is due to better and easily approachable health facilities provided to gas victims.

Incidence of exophoria with convergence insufficiency was more in case group as compare to control group. This group mostly involves female patients who were students or more involve in near work like tailor, teacher etc In study group out of 22 patients who were documented case of hypertension only 4 patients had hypertensive changes in fundus and out of 8 cases with documented diabetes mellitus only 2 patient have diabetic retinopathy. In control group out of 16 patients who were documented cases of hypertension only 2 patients had hypertensive changes in fundus and out of 6 cases with documented diabetes mellitus only 2 patients have diabetic retinopathy. All the cases in study and control group having hypertensive changes and diabetic retinopathy were having history of uncontrolled hypertension and diabetes mellitus of > 10yrs. Age related macular degeneration was found in patients >50yrs of age. The fundus changes were due to long duration of systemic disease in patients and also increase life expectancy of the individuals with the systemic disease.

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