Bull. Environm. Contam. Toxicol. 29, 412–415 (1982)

Effect of Cadmium on Meiosis[1]

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Cadmium is a recognized health hazard to miners and exposed industrial workers, most notably producers of alkaline batteries. Cadmium may be an etiological factor in various pathological processes including testicular tumors (FLICK et al. 1972). Cadmium has been shown to produce reproductive toxic effects (DWIVEDI et al. 1977), testicular necrosis (CLEGG & CARR 1967) in rats, and congenital malformations in hamsters (HOLINBERG & FERM 1969). Cadmium affects spermatogenic cells and significantly decreases fertility (LEE & DIXON 1973). In the present investigation, the effect of cadmium on meiosis during spermatogenesis has been studied in male rats.

MATERIALS AND METHODS

Adult male albino Sprague-Dawley rats of proven fertility and kept on ad-libitum diet were used. Rats were divided into three groups and each group had six rats. The first group served as a control and animals of this group were injected with an equivalent amount of saline solution. The second and third groups were injected intraperitoneally with cadmium as cadmium chloride at dosages of 5 and 10 µmole/kg, respectively. Three animals from each group were sacrificed at 48 and 72 h after injection. Testes were removed and minced in a Petri dish and was placed in 0.075% KCl for 20 min. After centrifugation, cells were fixed in 3:1 methanol and acetic acid for h. The cells were air-dried on glass slides and stained with Giemsa (SINGH & GARLICK 1972). Count of chromosome number at dysjunction or precocious separation of homologous and sex chromosomes was done and the degeneration of sex vesicles at early prophase and tetrapolid cells at methaphase I and II was scored and was compared with control data. At least three hundred cells were counted from each slide.

1. This research was supported by Maternal and Child Health Care Training Grant #440
2. Supported by the National Foundation March of Dimes
3. To whom enquires should be directed

0007-4861/82/0029-0412 $01.00

Statistical comparisions were made by the two-tailed grouped student's t test. The level of significance chosen in all cases was $p < 0.05$.

RESULTS AND DISCUSSIONS

The effect of cadmium on meiosis is shown in Table 1. The cell counts from the slides of control rats showed 8.8% degeneration of sex vesicles and 2.7% tetraploidy. However, precocious separation was not seen in control rat slides. Cadmium at a dosage of 5 μmole/kg after 48 h produces 31.3% degeneration of sex vesicles, 6.4% precocious separation of sex chromosomes, and 3.7% tetraploidy; and after 72 h produced 42.3% of degeneration of sex vesicles, 12.5% of precocious separation, and 3.6% tetraploidy. The degeneration of sex vesicles was significantly different from the control group ($p < 0.05$) at both time intervals. Cadmium at a dosage of 10 μmole/kg after 48 h showed 33.3% of degeneration of sex vesicles, 3.9% of precocious separation, and 7% tetraploidy; and after 72 h produced 54.5% of degeneration of sex vesicles, 2.7% precocious separation of sex chromosomes, and 5.3% tetraploidy. The degeneration of sex vesicles was significantly different from the control group ($p < 0.05$) at both time intervals. However the values at 5 and 10 μmole/kg were not significantly different from each other. Tetraploidy observed at 10 μmole/kg was significantly different from the control group ($p < 0.05$) at both time intervals. However the tetraploidy observed at 5 μmole/kg was not significantly different from the control group ($p < 0.05$).

Table 1. Effect of Cadmium on Meiosis

Treatment, μmole/kg	Time of Sacrifice h	Degeneration of Sex Vescicles %	Precocious Separation %	Tetraploidy %
0	-	8.85	-	2.7
5	48	31.3*	6.4	3.7
5	72	42.3	12.5	3.6
10	48	33.3*	3.9	7.0*
10	72	54.5*	2.7	5.3*

*Significantally different from control ($P < 0.05$)

These results indicate that cadmium produces degeneration of sex vesicles, precocious separation of sex chromosomes, and tetraploidy. Increased occurrence was observed at 72 h than at 48 h after the cadmium injection and at the higher dosage of 10 μmole/kg than at 5 μmole/kg. However, a significant tetraploidy was observed only at 10 μmole/kg.

Cadmium produces selective toxic effect on testes. Cadmium causes testicular damage at as low dosage as 1.1 to 2.2 mg/kg

without pathological damage to other tissues. A single high dosage of 10 mg/kg produces selective destruction of rodent testes (PARIZEK & ZAHOR 1956). Similar results have been reported by others (PARIZEK 1957, MEEK 1959, KAR & DAS 1960, GUNN et al. 1963, ALLANSON & DEANELSY 1962). Cadmium-induced testicular injury could be explained either due to a circulatory failure due to vascular damage (GUNN et al. 1963, CHIQUOINE 1964, SETCHELL & WAITES 1970) or due to a direct action of cadmium on spermatogenic cells. The requirement of zinc for the maintenance of germinal epithelium (ELCOATE et al. 1955, & MILLER et al. 1960) and protective action of zinc for the cadmium-induced toxicity suggests the latter as the possible mechanism (PARIZEK 1957). DIMOW & KNORRE (1967) demonstrated changes in the enzymes of the germinal epithelium; DWIVEDI et al. (1977) reported the changes in spermatozoan enzyme prior to histological changes in the testes. These results are most consistent with a direct action of cadmium on the germinal epithelium. LEE & DIXON (1973) con cluded that the primary action of cadmium seems to be an effect on zinc utilization by spermiogenic cells as well as an inhibi tion of deoxyribonucleic acid synthesis by spermatogonial cells.

The results from the present study have shown that cadmium produces precocious separation of sex chromosome, tetraploidy, and degeneration of sex vesicles. Due to high affinity of cadmium towards the sulfhydryl and disulfide groups, the biochemical basis of cadmium sought through cadmium-sulfur interaction (GABER & FLUCHARTY 1968, DWIVEDI 1982). The effect of cadmium on cell division presumably is due to interaction with sulfhydryl groups of the protein units forming the cell spindle.

The human daily intake of cadmium in the United States is as much as 200 to 500 ug (TIPTON & STEWART 1970). Cadmium is not considered as an essential element. However, this element is accumulated progressively with age in the living organism (SCHROEDER 1967). As is evident from this study, cadmium could interfere with spermatogenesis in rats and may be a potential reproductive hazardous element for the human.

Acknowledgement. Grateful acknowledgement is made to K. Davis for technical assistance and to R. Strickland for secretarial assistance.

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Accepted July 12, 1982