INTRODUCTION

Metabolic syndrome (MS) is a group of risk factors including hypertension, hyperglycemia, hypertriglyceridemia, low high density lipoprotein (HDL) cholesterol, and central obesity. Organochlorine pesticides (OCPs) are a group of Persistent Organic Pollutants such as Hexachlorocyclohexane (HCH) and its isomers, aldrin, dieldrin, α-endsulfan, β-endsulfan, p, p’- Dichloro-diphenyl-trichloro-ethane (DDT), and p, p’-DDE (Dichloro-diphenyl-dichloro-ethylene) are endocrine disrupting chemicals stored in adipose tissue because of their persistence in the environment and high bioaccumulative nature. OCPs have also been shown to have a strong association with insulin resistant type 2 diabetes. Only a few earlier studies have revealed an association between OCPs and MS.

Aim

- To measure serum OCP levels in patients of MS and control subjects.
- To identify differences, if any, in serum OCP levels, in patients with MS and control subjects.
MATERIALS AND METHODS

Cross-sectional study was conducted in the Departments of Medicine and Biochemistry at University College of Medical Sciences (UCMS) and Guru Teg Bahadur (GTB) Hospital, Delhi. For identification of MS, we used National Cholesterol Education Program (NCEP) Adult Treatment Panel (ATP)-III criteria modified as per International Diabetes Federation (IDF) (hypertension ≥130/≥85 mmHg or on medication, fasting plasma glucose ≥110 mm/dL or on medication, HDL cholesterol <40 mg/dL (men) or <50 mg/dL (women), plasma triglycerides (TGs) ≥150 mg/dL or on medication, waist circumference ≥90 cm for males and ≥80 cm for females). There were a total of 100 subjects divided into two groups. Group I: Fifty individuals ≥18 years, with MS (study group) and Group II: 50 individuals with age and sex matched controls. Serum OCPs were measured and the levels in the two groups were compared.

Exclusion criteria
- Persons having chronic occupational exposure to OCPs such as workers of pesticide factories,
- Recent exposure to OCPs within 4 weeks

Waist circumference was measured midway between the inferior margin of rib cage and iliac crest. Plasma glucose was analyzed using glucose oxidase/peroxidase method. The blood pressure was measured after a 5 min rest in the right arm in the supine position. Three readings were taken at 5 min intervals and their mean was taken as the final reading. Blood was drawn after 8 hours of overnight fasting. Total cholesterol and triglycerides was estimated by enzymatic method. HDL cholesterol was estimated in serum by turbidimetric immunoassay. Serum very low density lipoprotein (VLDL) was estimated using the formula VLDL = TG/5. Serum low density lipoprotein (LDL) was determined from the Friedewald’s formula, LDL = total cholesterol-(HDL + VLDL).

Quantification of OCP levels was done by Perkin Elmer GC equipped with 63Ni selective electron capture detector. The limit of detection (LOD) was 4 picogram/mL (pg/mL) for each OCP.

Statistical analysis
The data for all the groups was expressed as mean ± standard deviation. The physical, biochemical parameters and levels of OCPs in cases and controls were compared by independent t-test. Risk of having MS with OCPs was calculated by using logistic regression analysis.

RESULTS

Table 1 shows data for waist circumference, body mass index (BMI), blood pressure, fasting blood glucose, HDL, and TGs of both cases and controls.

Although, OCP levels of cases were higher as compared to controls but only in case of β-HCH the mean value (8.40 ± 8.64 ng/ml) was significantly (P < 0.001) higher as compared to controls (2.58 ± 2.34 ng/ml). Table 2 shows the data for levels of all nine OCPs.

After adjusting for confounding factors like age, sex, smoking, alcohol, and BMI, β-HCH as well as aldrin showed an association with MS. Adjusted Odds Ratio (ORs) for β-HCH and aldrin were 1.34 (95% CI = 1.14–1.57) and 1.23 (95% CI = 1.01–1.50), respectively. Table 3 shows the risk of having MS with all nine OCPs after adjustment of confounders.

DISCUSSION

In our study, mean serum levels of all nine OCPs were higher in cases as compared to controls. Mean level of

---

Table 1: Physical and biochemical data for cases and controls

| Parameters                | Mean±SD (n=50) | P value*     |
|---------------------------|----------------|--------------|
| Waist circumference (cm)  | 99.94±12.12    | <0.001*      |
| Blood pressure (mmHg)     | 145.40±18.69   | <0.001*      |
| Fasting blood glucose (mg/dl) | 122.74±39.49   | <0.001*      |
| HDL cholesterol (mg/dl)   | 35.64±8.08     | <0.001*      |
| Triglyceride (mg/dl)      | 208.30±23.68   | <0.001*      |

*independent t test, P<0.05 is statistically significant, SD: Standard deviation

Table 2: Levels of organochlorine pesticide in cases and controls

| OCPs (ng/ml) | Mean±SD (n=50) | P value*     |
|--------------|----------------|--------------|
| α-HCH        | 2.93±5.42      | 0.832        |
| β-HCH        | 8.40±8.64      | <0.001*      |
| γ-HCH        | 2.34±5.40      | 0.414        |
| α-endosulfan | 1.80±4.20      | 0.587        |
| β-endosulfan | 1.41±1.47      | 0.618        |
| p, p’-DDE    | 2.32±3.26      | 0.467        |
| p, p’-DDT    | 1.62±1.43      | 0.477        |
| Aldrin       | 3.46±5.20      | 0.087        |
| Dieldrin     | 2.22±3.51      | 0.773        |

*independent t test, P<0.05 is statistically significant, SD: Standard deviation, HCH: Hexachlorocyclohexane, DDE: Dichloro-diphenyl-dichloro-ethylene, DDT: Dichloro-diphenyl-trichloro-ethane
**Conclusion**

The results of our study suggest that background environmental exposure to some OCPs, especially β-HCH and aldrin, may be involved in the pathogenesis of metabolic syndrome. This highlights the need for active interventions on a national scale restricting the use of OCPs and there replacement by safer and environment friendly alternatives.

### References

1. Rekha, Naik SN, Prasad R. Pesticide residue in organic and conventional food-risk analysis. Chem Health Saf 2006;13:12-9.
2. Fisher BE. Most unwanted. Environ Health Perspect 1999;107:18-23.
3. Lee DH, Lee IK, Song K, Steffes M, Toscano W, Baker BA, et al. A strong dose-response relation between serum concentrations of persistent organic pollutants and diabetes: Results from the National Health and Examination Survey 1999-2002. Diabetes Care 2006;29:1638-44.
4. Lee DH, Lee IK, Jin SH, Steffes M, Jacob DR. Association between serum concentrations of persistent organic pollutants and insulin resistance among non-diabetic adults: Results from the National Health and Nutrition Examination Survey 1999-2002. Diabetes Care 2007;30:622-28.
5. Lee DH, Lee IK, Porta M, Steffes M, Jacob DR. Relationship between serum concentrations of persistent organic pollutants and the prevalence of metabolic syndrome among non-diabetic adults: Results from the National Health and Nutrition Examination Survey 1999-2002. Diabetologia 2007;50:1841-51.
6. Park SK, Son HK, Lee SK, Kang JH, Chang YS, Lee DH, et al. Relationship between serum concentrations of organochlorine pesticides and metabolic syndrome among non-diabetic adults. J Prev Med Public Health 2010;43:1-8.
7. Bush B, Snow J, Koblitz R. Polychlorobiphenyl (PCB) congeners, p, p'-DDE, and hexachlorobenzene in maternal and fetal cord blood from mothers in Upstate New York. Arch Environ Contam Toxicol 1984;13:517-27.
8. Tanabe S, Kunisue T. Persistent organic pollutants in human breast milk from Asian countries. Environ Pollut 2007;146:400-13.
9. Willett KL, Ulrich EM, Hites RA. Differential toxicity and environmental fate of hexachlorocyclohexane isomers. Environ Sci Technol 1998;32:2197-207.
10. Agency for Toxic Substances and Disease Registry (ATSDR) (2002). Toxicological profile for aldrin/dieldrin. Atlanta: U.S. Department of Health and Human Services, Public Health Service. Available from: http://www.atsdr.cdc.gov/toxprofiles/tp1.pdf [Last accessed June 1st, 2013].

**Table 3: Risk of metabolic syndrome with OCPs**

| OCP          | Odds ratio | 95% confidence Interval | P value* |
|--------------|------------|-------------------------|---------|
| α-HCH        | 1.07       | 0.92 - 1.26             | 0.370   |
| β-HCH        | 1.34       | 1.14 - 1.57             | <0.001* |
| γ-HCH        | 1.02       | 0.79 - 1.32             | 0.886   |
| α-endosulfan | 0.975      | 0.81 - 1.17             | 0.781   |
| β-endosulfan | 0.99       | 0.67 - 1.49             | 0.985   |
| p, p’-DDE    | 1.01       | 0.81 - 1.26             | 0.928   |
| p, p’-DDT    | 1.02       | 0.65 - 1.59             | 0.945   |
| Aldrin       | 1.23       | 1.01 - 1.50             | 0.045*  |
| Dieldrin     | 1.02       | 0.81 - 1.27             | 0.901   |

*Logistic regression analysis (with adjustment for age, sex, smoking, alcohol). P<0.05 is statistically significant, SD: Standard deviation, HCH: Hexachlorocyclohexane, DDE: Dichloro-diphenyl-dichloro-ethylene, DDT: Dichloro-diphenyl-trichloro-ethylene

β-HCH in cases was significant higher (P < 0.001). After adjustment for confounding factors the risk of having MS with β-HCH in study group was found to be 1.34 times higher as compared to control group (P < 0.001). β-HCH is the most persistent OCP still in use in developing countries like India and China. It is more persistent and more slowly cleared from the body than other isomers, and is, therefore, the easiest isomer to detect in humans and is most likely to affect individual health chronically. Similarly, risk of developing MS with exposure to aldrin was 1.23 times higher as compared to controls (P = 0.045). Aldrin is an OCP which was widely used in agriculture and public health programs in India. Because of low water solubility and tendency to bind strongly to soil, aldrin migrates downwards very slowly through soil, or into surface or ground water (ATSDR 2002). This pesticide may also be associated with adverse neurological and reproductive effects.