Poisoning from DDT and Other Chlorinated Hydrocarbon Pesticides: Pathogenesis, Diagnosis and Treatment

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The wide-spread use of chlorinated hydrocarbons, such as DDT, in agriculture, animal husbandry, and about the home has been accompanied by a syndrome of hepatic and neurologic damage, and sometimes death. Animal experiments (5, 14, 16, 19, 23, 26, 32, 36, 39, 43, 47, 48) and human experiments (4, 9, 20, 21, 42, 46) have shown that DDT and similar insecticides can cause this type of damage. In this clinic over one hundred cases of this syndrome have been placed on record in the last year. But until the introduction of fat biopsies there was no way of proving whether or not insecticides were the etiological agents in living patients. To prove the diagnosis of insecticide poisoning in a living patient one must show three things: 1) typical symptoms, 2) evidence of characteristic pathology, and 3) presence of insecticide in the patient's tissues. This paper presents the first reported series of cases in which all three of the above requirements have been satisfied.

The properties that make chlorinated hydrocarbons poisonous to insects also make them poisonous to mammals. Lauger, Martin, and Muller (27) in 1944 postulated the two characteristics which make these compounds harmful, and without which they cannot be harmful. First, the molecule must have a toxic component which probably interferes with an essential enzyme system. Parachloro, fluoro, and methoxy substituted phenyl rings are outstanding in this connection. Second, the molecule must have a lipophilous component which causes the chemical to accumulate in fat, such as nerve lipids. This allows the concentration to build up to a damaging level. These postulates were confirmed in 1946 by Kirkwood and Phillips (23). In the same year, Roeder and Welant (39) of Tufts College showed that the tremors characteristic of DDT poisoning in the cockroach are due to an intense bombardment of the motor neurons and that the bombardment originates in the afferent nurons. They demonstrated a series of high frequency trains of axon spikes in the afferent neurons; these reactions resulted from DDT perfused through the leg of a cockroach in concentrations as low as 0.01 parts per million. They found that it took concentra-

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tions above 1,000 parts per million to affect the motor neurons directly. The earlier work of Yeager and Munson (49) dealt only with this latter phase, but it gave a classic description of the symptoms of toxicity in the DDT poisoned roach [which have also been described in the housefly (24)]: "Increased activity, the eventual appearance and persistence of contraction and tremors in the appendages and body, erratic behavior, and loss of equilibrium."

These same symptoms in humans after exposure to comparable doses of DDT were described by Biskind and Bieber in 1949 (6). The most common symptom was extreme apprehensiveness. Also of importance were excitement, hyperirritability, anxiety, confusion, inability to concentrate, inattentiveness, forgetfulness, and depression. These observations were confirmed by Lejman (30). Biskind and Bieber also observed headache, insomnia, and disturbances of equilibrium. When DDT attacks the autonomic nervous system, tachycardia, dermal ischemia, sweating of the palms, and a sense of impending syncope result. Biskind reports that this is followed by bradycardia, flushing of the skin, relaxation and cessation of palmar perspiration. Some investigators have intentionally exposed themselves to DDT to note ensuing symptoms. R. A. M. Case and a colleague (9) exposed their skins to DDT in 1945. They noted tiredness, heaviness, and aching of the limbs. There was extreme irritability as well as a great distaste for work of any sort. They complained of a feeling of mental incompetence and also suffered from severe joint pains. In the same year V. O. Wigglesworth (46) put an acetone solution of DDT on his skin for a brief length of time. He noted extreme nervous tension and anxiety as sequelae. He was completely disabled for ten weeks and had not entirely recovered at the end of a year.

According to Lauger's postulates, chlorinated hydrocarbons should be able to damage any organ that has enough fat content to let them accumulate until they reach a damaging level. Such has proven to be the case in laboratory mammals. The liver has been found to suffer regularly from these insecticides (5, 16, 36, 35, 40, 41). Kidney damage was found (35, 36); necrosis of voluntary muscles (16, 36, 40); thyroid damage (36, 40); nerve tissue damage (35, 40); and rare myocardial and adrenal lesions (36) have been described. The dermatitis which has been described (35, 36) may result from impairment of fat metabolism (38).

The pathologic lesions that appeared in the above-named organs was as follows:

LIVER—Hypertrophy of the centrolobular cells with an increased cytoplasmic oxyphilia, plus increased basophilia and margination of the cytoplasmic granules, and a tendency to hyalinization of the remainder of the cytoplasm. There was frequently a centrolobular hepatic cell necrosis superimposed which appeared to be of recent origin (16).

KIDNEY—Renal lesions were infrequent, except in rabbits. Nelson, Draize, Woodward et al (36) found a focal tubular and interstitial lesion in the kidney.

THYROID—Loss of colloid; epithelial desquamation (36).

NERVE TISSUE—Partial tigrolysis of anterior horn cells with pericellular vaculation; loss of Nissl bodies in the reticulated lightly basophil cytoplasm of the anterior horn cells and pericellular regions and presence of paranuclear vacuoles. Generally the physiological changes are much greater than the morphological changes (32).

SKIN—Hyperkeratosis and thickening of the stratum spinosum; occasional slight cellular infiltration in the underlying corium; slight focal epidermal necrosis.

In cases of human deaths from insecticide poisoning the pathological changes were similar to acute poisoning changes in animals (4, 21). The reported cases of insecticide deaths were the spectacular ones, involving swift death from massive exposures. Pathological diagnosis was made at autopsy (4, 21, 20, 42). But many other patients die slowly from insecticides without the true cause of their death being recognized.

The following work shows how easily such toxicity might escape notice. Haag, Finnegan, and co-workers (19) reported increased mortality in rats from chronic chlorinated hydrocarbon insecticide toxicity. Yet the tissues of these animals showed few pathological changes at autopsy; the tissues of some animals showed no changes at all. In short one could not prove the diagnosis of insecticide toxicity in these animals by clinical or laboratory methods. But their lives were shortened by insecticides.

We shall never know how many humans suffer similarly. Only the outstanding cases come to public notice.

During 1949 three hundred cases of occupational illness and one fatality from agricultural chemicals were reported in California alone. Thirty of these were definitely from chlorinated hydrocarbon insecticides (2); there was a possibility that 117 of the others may have resulted from the same cause.

There are three ways by which humans absorb insecticides, but there are many by which they are exposed to them. Toxic doses can be absorbed through the skin (14, 18, 41), through the gastrointestinal tract (4, 19, 21, 36, 41) and through the lungs (19, 35). Chlorinated hydrocarbons are so commonly used to kill flies about the house that almost everyone gets exposed. Some cities have a "Spray Day" when everyone is expected to spray his home and environs thoroughly with one of the chlorinated hydrocarbons (37). In other cities, airplanes drop a blanket of DDT (3, 11, 33), thereby exposing all of their inhabitants. Insecticides are used on most farm crops and on many meat and dairy animals (34). Toxicity may result from eating the fruits and vegetables directly sprayed or from eating others grown the following season on the same soil: the later crop picks up the insecticide through its roots, stems, or leaves (10, 11). Toxic concentrations have been found in the meat of cattle who ate sprayed forage (8). Carter, Hubanks, Mann, Alexander and Schopmeyer (8) cooked this meat by five different methods to see if cooking had any effect on the concentration of DDT. They roasted, broiled, pressure-cooked, braised and fried different samples of meat, but they found the concentration of unmodified DDT to be the same after cooking as it was before.

Chlorinated hydrocarbon residues are commonly found on fruits and vegetables (44), but they are not considered dangerous unless they contain over 0.049 grains per pound (5.4 p.p.m.), (the tolerance allowed by the U.S. Food and Drug Administration). *The concentration of DDT on some crops has been found to be three times this level when there was inadequate rain (17).* DDT has also been found in milk: In 1945 Woodard, Ofner, and Montgomery (49) showed that if a dog ate DDT, the insecticide would be excreted in the milk. Later in the same year Telford and Guthrie (43) showed that it was transmitted into the milk of white rats and goats that digested it. The U.S. Department of Agriculture issued a notice (45) on April 7, 1949, advising that insecticides containing DDT should not be used directly or indirectly on dairy animals or on their feed or on the feed of animals being finished for slaughter. The notice stated that DDT had been found in the milk even when it was used for ordinary fly control in the barn.

The U.S. Food and Drug Administration advises that there should not be over one part per million of DDT in the food a person eats if all the food is contaminated. If only one food is contaminated, the Administration advises that it should not contain over five parts per million (13, 29). In common terms, one teaspoon of DDT mixed through ten tons of food is one part per million. These limits were obtained by rat experiments (28) because rats appear to react similarly to man in their tolerance to these toxins. However, Arnold J. Lehman, chief of Pharmacology of the U.S. Food and Drug Administration pointed out that human tolerances are not really known and that it might take ten years after exposure to find all the important facts (7).

The toxic potentialities of chlorinated hydrocarbon insecticides are increased by the fact that the body can store them. Exposure to one subtoxic dose may not produce any detectable damage, but some of the insecticides will be retained in the body fat. Repeated exposures may increase this store until it reaches a toxic level (26). Woodard, Ofner, and Montgomery (48) found the concentration of DDT in the fat of five of their experimental dogs to be many times the lethal intravenous dose (0.04 mgm. per gram of body weight). The dogs had managed to stay alive by keeping the DDT out of circulation. (The animals in question had 4.94, 1.65, 0.67, 0.39, and 0.08 mgm. per gram of body weight respectively in their fat). Toxicity arises when the animal draws on its fat for energy. As the fat is used up, the stored insecticides are released into the blood. Fitzhugh and Nelson (16) found that the concentration in the blood can reach the level of acute toxicity under these circumstances.

The body's first method of protecting itself against these toxins is to excrete them. Evidence has been presented that chlorinated hydrocarbons are excreted in the bile and in the urine (25, 41). Suggestive evidence that the liver may detoxify the body is found in the work of Jandorf, Sarett, and Bodansky (22) who found that the oxygen consumption of the liver rises when rats are fed DDT. Proof has been presented that DDT disappears from the fat when administration is stopped (26, 48).

How long it takes to detoxify, so that signs and symptoms disappear, depends on the individual. Even with treatment, several months are usually required. The only quantitative investigation of this matter which we could find was done on laboratory animals. In rats 25% of the DDT was still present in the fat three months after exposure was stopped (26).

Exposure to high concentration of chlorinated hydrocarbons or the presence of them in the body does not always result in toxicity. If these insecticides are not dissolved in organic solvents, they are less toxic than if so dissolved (4, 21, 41, 48). Also tolerance varies greatly among individuals and among species (19, 36). I. Gordon (18) reported cases of massive exposure to DDT in an organic solvent among natives in British West Africa in which the subjects showed no signs of toxicity. One case has been reported of a man who had no symptoms in spite of having 200 parts per million of DDT in his fat (31). In the cases presented in this paper there was great variance in individual susceptibility, some patients showing toxicity on only slight exposure. It is not possible to predict at this time how much any one individual can stand without injury. As Draize, Nelson, and Calvery (14) have shown, death and debility need not result from the direct action of insecticides; they often result from secondary infections which follow toxic anorexia and emaciation.

The following case abstracts are of patients who presented 1) typical symptom and signs of chlorinated hydrocarbon poisoning; 2) evidence of liver pathology; 3) chlorinated hydrocarbon detectable in fat removed by biopsy. The determinations of pesticide in the fat biopsies were done by the U.S. Food and Drug Administration under the direction of A. J. Lehman. The findings were reported in terms of DDT equivalent. We have found the blood cholesterol level and icteric index to be the most sensitive clinical tests for liver disease; and they were found disturbed in this series of cases. By the methods that our laboratory used the normal range of blood cholesterol is 140-180 mgms., and the normal icteric index is 4-6. In addition to the treatment noted, all patients received a high protein diet, with high vitamin content, plus lecithin (Lecithin contains choline and is lipotropic).

CASE REPORTS:

1. PATIENT 14099: Male, age 43, rancher, first seen March 27, 1949.

SYMPTOMS AND SIGNS: *March 28, 1949* palate cyanotic. Left patellar reflex is clonic. Antebrachial reflexes hyper-active. *April 26, 1949,* circum-orbital bronzing. *June 1949* felt weak. *September 1949* began to feel a bit better.

February 2, 1950 extreme irritability, anxiety, exhaustion, weakness, anorexia, diarrhea, icterus, circum-orbital bronzing.

EXPOSURE: had been using DDT spray about the ranch for many months.

EVIDENCE OF DISEASE: *March 28, 1949* blood cholesterol 151 mgms. (normal), hemoglobin 12.5 gms, leucocytes 14,000, sedimentation rate 5 mm/60 mins. *February 7, 1950* cholesterol 190 mgms., icteric index 8.4, sedimentation rate 5mm/60 mins., hemoglobin 14.8 grms., leucocytes 19,600.

FAT BIOPSY: Taken *February 7, 1950,* contained 15 parts per million DDT.

TREATMENT: Crude liver extract, adrenal cortical hormones. Has been improving since under treatment, but has not fully recovered.

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2. PATIENT 13592: Female, age 45, housewife, first seen *February 20, 1948.*

SYMPTOMS ANDS SIGNS: Low energy, gastrointestinal upsets, back ache. Enlarged non-tender liver which persisted through March 13, 1950.

EXPOSURE: Believes that chlorinated hydrocarbon insecticides were used on the fruits and vegetables she bought.

EVIDENCE OF DISEASE: *February 20, 1948* hemoglobin 14.2 gms., blood cholesterol 200 mgms., sedimentation rate 32 mm/60 mins., *July 1, 1949* hemoglobin 12.2 gms., blood cholesterol 180 mgms., icteric index 5.5, sedimentation rate 88 mm/60 mins.

FAT BIOPSY: Taken *September 14, 1949,* contained 4.6 parts per million DDT.

TREATMENT: Adrenal cortical hormones, crude liver extract. Recovery has been slow, but symptoms are disappearing.

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3. PATIENT 14286: Male, age 44, dentist, Commander in U.S. Navy during World War II, first seen *September 1, 1949.*

SYMPTOMS AND SIGNS: Disseminated dermatitis, stiffening of all the joints of the body. Had suffered from fatigue since discharge from Navy in 1945, gradually lost 28 lbs. Generalized erythematous rash about the face, the upper portion of the thorax, and a butterfly distribution about the bridge of the nose and the malar prominences. Yellow cast to fundi.

EXPOSURE: Heavy exposure to DDT while stationed at Midway from August 1943 to July 1944. Also exposed August 1944 to May 1945. Had been using an aerosol bomb about the house recently.

EVIDENCE OF LIVER DISEASE: *September 2, 1949* blood cholesterol 208 mgms., hemoglobin 13.8 gms., sedimentation rate 12 mm./60 mins. *February 3, 1950* blood cholesterol 201 mgms., hemoglobin 12.9 gms., sedimentation rate 4 mm./60 mins. *March 11, 1950* cholesterol 216 mgms., hemoglobin 14.8 gms., sedimentation rate 5 mm./60 mins.

FAT BIOPSY: Taken *October 12, 1949,* contained 10 parts per million DDT.

TREATMENT: Commencing *September 2, 1949* patient took lethicin orally. Five months later blood cholesterol had dropped slightly, but was still above normal. Sedimentation rate had fallen to normal, but hemoglobin had fallen also. Five weeks later cholesterol was found to have risen, so patient was started on adrenal cortical hormone and injections of crude liver extract. Patient improved notably on this regime.

4. PATIENT 13236: Female, age 37, wife of rancher, first seen *November 10, 1947.*

SYMPTOMS AND SIGNS: Poor appetite, low vitality, sore throat, headaches, shortness of breath, incontinence, mental confusion, vertigo, air hunger, feeling of fullness in chest, mediastinal pain, intermittent constipation and diarrhea, Icterus; poor muscle tone. In *August 1949* developed acute mental upset with schizophrenic tendencies.

EXPOSURE: DDT and chlordan were used about the barn where the family cow was kept. Exposure continued all the time she was under treatment.

EVIDENCE OF LIVER DISEASE: *November 10, 1947* blood cholesterol 212, hemoglobin 12.0 gms., sedimentation rate 4mm/60 mins.; *August 15, 1949, cholinesterol* 240, hemoglobin 12.1 gms., sedimentation rate 5mm./60 mins.

FAT BIOPSY: Taken *August 31, 1949,* contained 10.35 parts per million DDT.

TREATMENT: Adrenal cortical hormones, B complex vitamins, crude liver extract injections. Moved out of California and away from contact with insecticides. Since then has gradually recovered.

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5. PATIENT 12644: Male, age 37, agricultural inspector, first seen *June 7, 1945.*

SYMPTOMS AND SIGNS: Cramps and twitchings of muscles, frequent respiratory infections, stiffening of hand joints at night, low energy, pruritis of ears, left shoulder and hands; increased irritability, Edema of nasal and oral membranes. Cyanosis of oral membranes. Tendon reflexes hypoactive.

EXPOSURE: From 1936 to 1940 he had charge of the use of lead arsenate, cyolite, hydrocyanic acid, etc. From 1940 to 1946 he was agricultural inspector with the work of handling and grading fruits and vegetables for size and quality. On this job he worked with arsenate of lead. From 1946 to 1948 he worked in a date packing plant which he sprayed in the spring of 1947, covering the entire under part of the plant with a 50% DDT vegetable oil solution. He made three further applications of chlordan to the entire plant in 1947. Frequently used fly spray containing DDT in his office and home.

EVIDENCE OF LIVER DISEASE: *September 9, 1949,* blood cholesterol 246 mgms., icteric index 8.7. *December 22, 1949* bloor cholesterol 199 mgms., icteric index 9.4, *May 2, 1950* cholesterol 224 mgms., icteric index 8.7.

FAT BIOPSY: Taken *August 31, 1949* contained 18.3 parts per million DDT.

TREATMENT: Report on fat biopsy was not received until January, 1950. At this time injections of crude liver extract were begun. The patient's progress has been slow. Symptoms and signs have been partially relieved, but there is still much liver damage.

6. PATIENT 13734: Female, age 39, housewife, first seen *May 11, 1948.*

SYMPTOMS AND SIGNS: Rhinorrhea, low backache, lesion in mouth, clammy hands and feet, disturbed capillary return circulation in upper extremities. Cyanosis, Crepitus in many joints. Large, beefy, edematous tongue.

September 27, 1948: Dizziness, sneezing, low energy, lachrymation, abdominal discomfort, temporal headaches, circum-orbital bronzing, icteric selerae.

EXPOSURE: *March 25, 1949* her house was termite-proofed with a DDT preparation. The neighbors also used aerosol bombs extensively.

EVIDENCE OF LIVER DISEASE: *May 12, 1948* blood cholesterol 160 mgms., (normal); hemoglobin 13.8 gms. *August 5, 1949* blood cholesterol 182 mgms., hemoglobin 11.4 gms. *March 3, 1950* blood cholesterol 296, hemoglobin 14.4 gms. *March 22, 1950* icteric index 6:5.

FAT BIOPSY: Taken *September 14, 1949* contained 9.8 parts per million DDT.

TREATMENT: Adrenal cortical hormones, oral liver concentrate crude liver extract injections. Improved gradually after August 1950.

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7. PATIENT 14240: Female, age 51, housewife, first seen *August 3, 1949.*

SYMPTOMS AND SIGNS: Exhaustion, low energy, rough skin rash, circum-orbital bronzing, icterus of sclerae. Slightly disturbed dark adaptation of the eyes. Crepitus in many joints and poor muscle tone. Slight cyanosis of tissues of face and mouth. Edema of buccal membranes. Moist rales in right lower chest on coughing.

EXPOSURE: Periodic commercial spraying of garden and extensive use of DDT bombs in the house.

EVIDENCE OF LIVER DISEASE: *July 28, 1949* blood cholesterol 220 mgms., hemoglobin 14.4 gms. *August 17, 1949* cholesterol 222 mgms., icteric index 6.3. *September 22, 1949* cholesterol 204 mgms., icteric index 5.5, hemoglobin 13.3 gms.

FAT BIOPSY: Taken *August 31, 1949,* contained 23.6 parts per million DDT.

TREATMENT: Adrenal cortical hormones, oral liver. Patient improved steadily under treatment.

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8. PATIENT 14176: Male, 45, sales manager, first seen *June 16, 1949.*

SYMPTOMS AND SIGNS: Aches in knee and ankle joints, gastric distress on eating, erythematous rash over chest and back and over malar prominences of face. Disturbance of memory. Disturbed adaptation of eyes to darkness. Reduction of auditory acuity. Edema of oral and nasal membranes. Early in August showed icterus of sclerae, circum-orbital bronzing, increased erythema. Was given high liver feeding. In November had a coronary occlusion.

EXPOSURE: Spent considerable time in the San Joaquin Valley in early August when there was spraying; this was before exam. noted above.

EVIDENCE OF LIVER DISEASE: June *16, 1949* blood cholesterol 143 mgms., (normal). *September 2, 1949* cholesterol 206, icteric index 5.4.

FAT BIOPSY: Taken August 31, 1949 showed 10.6 parts per million DDT.

TREATMENT: Liver concentrate capsules orally, lecithin orally. Patient improved steadily.

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9. PATIENT 14042: Male, age 58, self-employed (heating-ventilating) first seen *January 28, 1949.*

SYMPTOMS AND SIGNS: Pain in right arm. Pain and crepitus in right shoulder. Dry skin. Lupus-like butterfly over nose. Buccal edema with slight purplish cast. Much crepitation in chest muscles. Gastrointestinal upsets. *February 20, 1949* had an accute attack of appendicitis. Appendectomy was performed; recovery was slow. Complained of tired feeling for several months afterward.

EXPOSURE: Had been spraying home with oil solution of DDT insecticide for several months before being examined.

EVIDENCE OF LIVER DISEASE: *January 28, 1949* blood cholesterol 200 mgms., hemoglobin 13.1 gms., sedimentation rate 25 mm./60 mins. *April 28, 1949* blood cholesterol 161 mgms. (normal) icteric index 5.9 (normal), hemoglobin 9.6, sedimentation rate 5 mm./60 mins. (normal).

FAT BIOPSY: Taken *September 14, 1949,* contained 9.64 parts per million DDT.

TREATMENT: Commencing *January 28, 1949* patient received injections of crude liver extract and oral liver concentrate for several months. By *April 29, 1949* the blood cholesterol had come down to normal, but the anemia was worse. Patient improved upon continuation of treatment.

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10. PATIENT 13711: Male, age 45, poultry breeder, first seen *April 19, 1948.*

SYMPTOMS AND SIGNS: Gradual loss of energy. Extreme air hunger for 15 months. Feeling of pressure in mediastinum. Slight erythematous rash on face and back and about eyes. Difficulty focusing eyes. Clamminess of extremities. Slight crepitus in wrists, ankles, shoulders. Examination showed eyes, heart and lungs to be normal.

EXPOSURE: Used 50% DDT powder in water to spray chicken ranch for fly control.

EVIDENCE OF LIVER DISEASE: *April 19, 1948* blood cholesterol 141 mgms. (normal), hemoglobin 14.6 gms. (normal), sedimentation rate 11 mm./60 mins. *December 16, 1949* cholesterol 219 mgms., icteric index 9.2. *March 3, 1950* cholesterol 179 mgms., icteric index 8.4, hemoglobin 16.4 gms., sedimentation rate 3 mm./60 mins.

FAT BIOPSY: Taken *September 14, 1949,* contained 9.2 parts per million DDT.

TREATMENT: Commencing *April 19, 1948* received oral adrenal cortical hormone daily to present. Has improved steadily.

DISCUSSION

Icterus is one of the most constant findings in the above cases, and a special word should be said about it because it often goes unnoticed. Slight icterus is becoming so common that some doctors fail to record it as an abnormal finding. We found this true in a series of 6 cases autopsied under the direction of Alvin Foord of Pasadena. Fat from these cadavers was found to contain DDT; (in one case 12 parts per million, in another 6 parts per million) there was gross and microscopic evidence of severe liver damage; yet there was no record that icterus had been observed. We have found that the color of the sclerae suggests liver damage some time before the icteric index rises above 6.

To diagnose a case of chlorinated hydrocarbon poisoning the following should be kept in mind:

1) *Neurological symptoms*—Hyperirritability, apprehensiveness, anxiety, excitement, confusion, inability to concentrate, inattentiveness, forgetfulness, depression, mental dullness, headache, insomnia, disturbances of equilibrium, fatigue.

2) *Liver damage signs*—Icterus, circum-orbital bronzing, poor digestion, constipation or diarrhea, poor appetite, elevation of blood cholesterol and elevation of icteric index.

3) *Exposure*—The patient may not be cognizant of his exposure. He may be consuming the toxin with his food or breathing it in from dust transmitted by winds. But it is worth asking about because he may be spraying his own house or garden; in this case he can stop the exposure.

4) *Confirmation*—If there is doubt, remove a 3 gram sample of the patient's fat and have it analyzed for chlorinated hydrocarbon insecticide content.

In addition to the ten cases which we have presented here, we have records of over one hundred cases of chronic insecticide poisoning in our files. We have taken fat biopsies from many of these patients and the analyses showed them to contain chlorinated hydrocarbon insecticides, sometimes in high concentrations, sometimes in low. It is difficult to estimate the incidence of this disease. Considering the ubiquitousness of these insecticides, their indestructability, and their profusion, we must conclude that there is ample opportunity for exposure.

In addition to DDT the common chlorinated hydrocarbon insecticides are chlordan, gamma isomer of benzene hexachloride, methoxychlor, and TDE. The following are trade names for one sixth of the chlorinated hydrocarbon insecticides listed by the California Department of Agriculture:

Agritox DDT dust, Phoenix Brand Dytox 5, Phoenix Brand Dytox 10, Butcher Brand Gesarol A-5 Dust, Butcher Brand D-5 Dust, Butcher Brand Gesarol A-10 Dust, "Our Own" "DDT" Dust No. 5, Persisto Dust No. 50, Persisto Dust No. 100, Persisto Dust No. 200 with adhesive, Persisto Wettable, Castle Brand Flea Powder containing DDT, Chemurgic Dust No. 10-D, Chemurgic Wettable No. 50-D, Dupont DDT, Dupont DEENAT 10-X, Dupont DEENAT 50-W, DDT

Dust 20, Gerasol AK50, Orchard Brand Genitox S-50, Genitox S-50 (DDT Wettable Powder), 50% DDT Spray Powder, Genitox S-50, DDT-50% Wettable, 50% DDT Wettable Powder, Lacco Brand Dust No. 9.5, Lacco Brand Wettable DDT Mixture, Lacco Brand Wettable DDT Mixture No. 1, Niagara Niatox Crop Spray, Niagara Niatox 5 Dust, Gravidide DT-Dust No. 10, Penco Pentech DDT, Prentox DDT Technical Grade, Shell DDT 50% Wettable DDTOL 50%, Wettable, No. 5 DDT Dust, SWC Live Stock Spray, Dampo 50, Denoxo 5, Denoxo 10, Dustrite DDT No. 50, Dustrite DDT Dust No. 100, Sunland D-5 Dust, Toxo DDT Dust No. 5, Toxo DDT Dust No. 10, Triangle Pest Dust No. D-5, United Brand DDT-Dust No. 5, Balley Brand 5% DDT Dust Moth Ded, Braun DDT Emulsion Concentrate MA-40, Bridegport Aerosol Insect Killer Mix No. 2.

It is difficult to protect people against insecticide exposure. We have already noted that some fruits and vegetables absorb chlorinated hydrocarbons from the soil; in these cases the insecticide cannot be removed from the plant. These compounds are very stable and are not affected by cooking. Peeling fruits and vegetables is beneficial where the insecticide has been sprayed on. But sometimes the chemicals become deeply incorporated in the tissue and cannot be removed. (15).

In treating toxicities caused by insecticides we have different problems in the acute and chronic cases. The aim in the acute case is to 1) remove any remaining insecticide by gastric lavage, skin washing or other means suitable to the type of exposure; 2) counteract the neurological symptoms by administering phenobarbital; 3) treat for shock when this is present; 4) put the patient on a program to protect his organs from later chronic toxicity.

The more common case is chronic toxicity. Our aim here is to build up the liver because it is the organ chiefly damaged. We have found the following program to be the most beneficial.

1) Crude liver extrac 4 units intramuscularly every other day for at least two weeks. This may be continued for months.

2) Choline daily. This may be given orally as lecithin one tablespoon three times a day, or it may be given as the pure choline 3 grams daily.

3) High vitamin diet. A cocktail of one tablespoon of raw grated liver in a glass of tomato juice daily is as an effective dose of Vitamins A, B and D.

4) A high protein diet is of benefit. Aside from the methionine for the liver, we get glumatic acid here which is a benefit to the nerve tissue.

CONCLUSIONS:

Chlorinated hydrocarbon insecticides are being used in all parts of the country. In 1948 thirty-five million pounds of DDT alone were produced (1). One teaspoon of DDT is enough to make two tons of food unsafe for eating. The hazard is increased by the fact that humans can absorb these insecticides through three different routes: the digestive tract, the lungs, and the skin.

Chlorinated hydrocarbons are stable and not amenable to decontamination. Organic solvents increase their toxicity. They produce neurological symptoms as well as those of liver damage. Pathological studies have shown that they can damage many organs besides the liver and nervous tissue. These insecticides accumulate in fat and may build up to a toxic level although the individual may never have received a single dose of toxic potency. Individual resistance varies greatly, but the presence of chlorinated hydrocarbon insecticides in a biopsy of a patient's fat should be considered a serious matter. Diagnosis can be made on finding 1) characteristic symptoms, 2) evidence of liver disease such as high blood cholesterol, and high icteric index, 3) presence of chlorinated hydrocarbon insecticides in a biopsy of the patient's fat. In the presence of a history of exposure and the typical subjective and objective findings, a fat biopsy is not always necessary. Many cases go unsuspected because of their chronic insidious nature and because slight icterus is so common that it often goes unnoticed.

Treatment of the disease is largely a matter of repairing damaged tissues. High protein and high vitamin diet, especially the B complex of vitamins, is useful. Injections of crude liver extract speed the process. Phenobarbital is of use in controlling the neurological manifestations.

Different governmental agencies have recognized the danger which these insecticides present. The U.S. Food and Drug Administration is now holding hearings to determine means of control. A Select Committee of the House of Representatives is also investigating the matter. (12).

SUMMARY:

1) The wide-spread use of chlorinated hydrocarbon insecticides has produced many cases of toxicity.

2) These insecticides accumulate in fat and principally damage fat-containing organs, as the liver and nervous tissue.

3) In the presence of characteristic signs, symptoms and blood studies, detection of chlorinated hydrocarbon insecticides in a biopsy of the patient's fat confirms the diagnosis of insecticide poisoning.

4) Chronic toxicity from these insecticides has been observed more frequently than acute toxicity.

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