DDT Poisoning and the Elusive "Virus X:" A New Cause for Gastro-Enteritis

By

MORTON S. BISKIND, M.D.

NEW YORK

DURING A PERIOD of more than two years, numerous cases of a curious symptom complex, apparently never before reported, have been observed throughout the United States. For want of a satisfactory explanation for this ailment, it has been widely attributed to infection with a thus far illusory "virus X."

The syndrome consists of a group of or all the following: Acute gastroenteritis occurs, with nausea, vomiting, abdominal pain, and diarrhea usually associated with extreme tenesmus. Coryza, cough and persistent sore throat are common, often followed by a persistent or recurrent feeling of constriction or a "lump" in the throat; occasionally the sensation of constriction extends substernally and to the back and may be associated with severe pain in either arm. In some cases the hyoid bone becomes acutely painful to pressure for a few days. Pain in the joints, generalized muscle weakness and exhausting fatigue are usual; the latter are often so severe in the acute stage as to be described by some patients as "paralysis." Sometimes the initial attack is ushered in by vertigo and syncope. Intractable headache and giddiness are not uncommon. Occasionally herpes zoster appears. Paresthesias of various kinds occur in most of the cases; areas of skin become exquisitely hypersensitive and after a few days this hyperesthesia disappears only to recur elsewhere, or irregular numbness, tingling sensations, pruritus or formication may occur. Erratic fibrillary twitching of voluntary muscles is common. Usually there is diminution of vibratory sense in the extremities.

After subsidence of the acute attack, irregular spasm of smooth muscle throughout the gastrointestinal tract often persists for weeks or months, associated with increased fatigability, which only gradually regresses. Febrile reactions occur occasionally during the initial stages but are not the rule. Except for a tendency to anemia, and in some cases a relative lymphocytosis, no constant changes are observable in the blood. Many of the patients have an acute bout of apprehension associated with the foregoing symptom complex and rarely is this relieved by reassurance as to the absence of physical findings sufficient to account for the severity of the disturbance.

Most striking about the syndrome is the persistence of some of the symptoms, the tendency to repeated recurrence of others over a period of many months (some patients fail to show complete recovery even after a year) and the lack of detectable lesions sufficient to account for the severity of the subjective reaction.

The high incidence, the usual absence of a febrile reaction, the persistence and erratic recurrence of the symptoms, the lack of observable inflammatory lesions, and the resistance even to palliative therapy, suggested an intoxication rather than an infection. Investigation for possible etiologic agents soon led to consideration of DDT (2, 2 bis (para-chlorophenyl) 1, 1, 1-trichloroethane; less precisely designated dichlorodiphenyltrichloroethane). The epidemic first appeared at about the time DDT came into widespread use by the civilian population. The signs and symptoms described in the pharmacologic and toxicologic literature as characteristic of DDT poisoning, are identical with those appearing in patients with the affection described (1, to 13).

Thus, among the disturbances which occur in known clinical poisoning with DDT are the following: acute gastroenteritis with nausea, vomiting, and abdominal pain, and diarrhea, coryza, cough, conjunctival irritation, a feeling of constriction in the throat and chest, dyspnea, persistent sore throat, giddiness, anxiety and apprehension, extreme lassitude, muscle weakness, fibrillary, spastic and even convulsive contractions of voluntary muscles, heaviness and aching of extremities, pain in joints, dermatitis, anemia, changes in the white blood cells and increase in blood calcium. In fatal cases of clinical DDT poisoning, tissue changes identical with those found in experimental poisoning in animals have been reported: degenerative changes in liver, kidney, spleen and adrenals, gastritis and enteritis with petechial hemorrhages throughout the gastrointestinal tract and hyperplastic changes in lymphoid follicles and Peyer's patches; pulmonary edema, bronchopneumonia, and changes in the blood vessels and cardiac musculature have also been reported.

Despite the fact that DDT is a highly lethal poison for all species of animals, the myth has become prevalent among the general population that it is safe for man in virtually any quantity. Not only is it used in households with reckless abandon, so that sprays and aerosols are inhaled, the solutions are permitted to contaminate the skin, bedding and other textiles are saturated, and food and food utensils are contaminated, but DDT is also widely used in restaurants and food processing establishments and as an insecticide on crops. Cattle, sheep and other food animals are extensively dusted with it and large areas are indiscriminately sprayed from airplanes for mosquito control. DDT is difficult and usually completely impossible to remove from contaminated foods (it is not affected by cooking) (14), and it accumulates in the fat and appears in the milk of animals who feed on

sprayed pasture or on contaminated fodder or who lick the DDT from their hides (14, to 16). As DDT is a cumulative poison (in animals repeated small doses are as lethal as single large ones) (17, to 20) it is inevitable that large scale intoxication of the American population would occur. In 1944, Smith and Stohlman (17) of the National Institute of Health, after an extensive study on the cumulative toxicity of DDT, pointed out, "The toxicity of DDT combined with its cumulative action and absorbability from the skin places a definite health hazard on its use."

Since low grade chronic intoxications from small amounts in foods are extremely difficult, if not impossible to trace, an effort was made to determine whether severe acute attacks of the type described could be related to known exposure to DDT. Patients complaining of the acute symptoms were therefore questioned as to prior exposure to this agent. A few illustrative cases are presented briefly:

Two patients developed acute gastroenteritis while at a vacation resort where kitchen and dining room were treated to frequent doses of DDT with an electric-powered aerosol device. In one of these patients, coryza and acute spasm of the lumbar musculature occurred at the same time. This was followed by a persistent sense of constriction and a feeling of a lump in the throat so severe that investigation was made for a possible neoplasm — none was found. Both these patients had subsequent repeated attacks of enteritis over a period of months and complained of continuous extreme fatigability, fibrillary twitching of muscles, irregular paresthesias and pain in the extremities. Eleven months later, some of the symptoms, while considerably less severe, were still present. One of these patients, some months after the original attack, was unknowingly exposed directly to a DDT aerosol used in a room connected by a partially open window with the room in which he was working. Within an hour there was recurrence of the sense of pharyngeal and substernal constriction, followed by nausea and abdominal discomfort. The next day the patient had coryza and diarrhea. Subsequently, both patients were exposed to DDT residues in an area that had been heavily sprayed. There was severe and persistent recurrence of all the symptoms in both cases.

Twenty-five patients with the "virus X" syndrome, were exposed directly to DDT spray or aerosol used to protect clothing from moths in a closet. In each case, within a few hours there was coryza, cough and conjunctival irritation to be followed next day by extreme debility, nausea, vomiting and diarrhea. The gastroenteritis persisted in each case for from one to four weeks, and increased fatigability, irregularly recurring malaise and other symptoms persisted for some months.

Twelve patients slept in beds sprayed with DDT at regular intervals (purely as a preventive measure — none had had bedbugs). Bedding, mattress and springs were indiscriminately saturated. All had repeated attacks of gastroenteritis with intervening intervals in which the main complaint was a disturbing sense of malaise. This is of interest in view of experimental poisoning in animals produced by contact with textiles saturated with DDT (17).

Another patient made a series of airplane flights to various parts of South America. During this trip he was repeatedly exposed to DDT aerosol used at a number of airports to prevent international transport of mosquitoes. In each case there was almost immediate irritation of the respiratory tract (other passengers complained of this too), with a sense of suffocation, cough and coryza, and giddiness. The patient's trip had finally to be interrupted when he developed a severe acute gastroenteritis and extreme muscular weakness requiring bed rest for 16 days. The enteritis, for which no etiologic agent could be found, persisted for weeks despite intensive therapy with sulfonamides, antibiotics and adsorbing agents.

In another case, while transferring a solution of DDT in kerosene from a spraying device to another container, the solution was spilled on the hands and not immediately removed. A residue of the original DDT solution contaminated the liquid subsequently used in the spraying device and to this the patient was also exposed. Acute gastroenteritis developed the next day; this persisted for two weeks. During this time coryza, sore throat and cough developed which subsided three weeks later. Extreme lassitude, pain in the joints and a disturbing sense of malaise persisted for weeks afterwards.

A patient with nutritional macrocytic anemia in whom the blood picture and nutritional state had been maintained for many months on adequate dosage of B vitamins, including folic acid, and liver, began to work weekends at an institution where she also took her meals. The patient noted that she invariably had a low grade nausea, occasional diarrhea and a sense of malaise, during and immediately following each of these weekends, but she dismissed these symptoms as possibly due to anxiety. When seen after several months of this regime, there was recurrence of the anemia despite continuation of previously adequate therapy. On inquiry it was found that the kitchen and dining room of this institution were regularly sprayed with DDT. The patient discontinued this employment and had no further attacks of gastritis though some malaise persisted and the anemia responded only very slowly to more intensive therapy.

Another patient in whose home DDT sprays were regularly used, had had repeated attacks of nausea, vomiting and diarrhea over a period of months and on several occasions was confined to bed owing to severe pain in the joints, muscular weakness, irregular paresthesias, and malaise. These attacks were invariably associated with severe apprehension.

In two further cases, patients working in an establishment where stored textiles were regularly sprayed with DDT for moth-proofing purposes, developed repeated attacks of gastroenteritis which persisted in each case for more than a month and was un-

responsive to any therapy. One of these patients, skeptical of any possible connection between her previous attacks and exposure to DDT, subsequently deliberately exposed herself to a DDT spray: nausea and severe abdominal pain supervened within a few hours, and diarrhea occurred subsequently. Two other skeptics who had had previous attacks of the syndrome described, re-exposed themselves, one to skin contamination with DDT solution, the other to DDT aerosol; both had prompt and severe recurrences which persisted for many weeks.

Altogether data have been accumulated on more than 200 cases of the "virus X" syndrome in which the condition followed immediately on known exposure to DDT.

On routine questioning of patients with the "virus X" syndrome as to exposure to DDT, I was surprised to find that more than a few of them had discovered for themselves that exposure to DDT spray or aerosol caused lachrymation, coryza, cough, "wheezing" and nausea. But all of them, completely convinced of the utter safety of DDT, dismissed these symptoms as unimportant.

As already indicated, a prominent feature in virtually all the patients was extreme apprehensiveness. This is probably explicable on the basis of functional and possibly even morphologic changes in the central nervous system produced by DDT, since in DDT poisoning in animals such disturbances are frequent.* This apprehensiveness (also reported in experimental DDT poisoning in man by Wigglesworth (1) and by Case (2) often made care of these patients extremely difficult since they were importunate both about diagnosis and the demand for relief. Infection with a hypothetical virus was distinctly unsatisfying as an explanation and no therapy appeared in any way to modify the course of the affection.

In some of the cases attributed to "virus X," observed at different times in different parts of the country, concomitant infection with actual known viruses, such as that of influenza and the common cold, is of course possible. This may have been responsible for failure thus far to consider the possibility basically of a toxic rather than an infectious agent.

DISCUSSION

The toxicology of DDT has been investigated extensively in a large number of species (17, to 24). It has been found almost without exception to be lethal to every form of animal life tested, the only limiting feature being the waxy nature of DDT and its solubility only in lipoids and lipoid solvents. It is largely this limited solubility which has been depended on (excessively, it now appears) to safeguard man and other mammals from poisoning.

In rats, mice, rabbits, guinea pigs, cats, dogs, chicks, goats, sheep, cattle, horses and monkeys, DDT produces functional and degenerative changes in the liver, gall bladder, kidney, spleen, thyroid, adrenals, ovaries, myocardium, voluntary musculature, central nervous system and peripheral nerves, gastrointestinal tract and blood (with variations depending on the species) (17, to 24). DDT is as lethal in repeated small doses as in larger single doses. In low-grade chronic poisoning in animals growth is impaired (20). The severe liver damage that results in these animals is not affected either by adequate protein (17) or by choline (20). In chronic administration by mouth no difference in toxicity is detectable between use of DDT in oil solution or in dry form (20). In chronic intoxication in rats there is a tendency to tumor formation in the liver (20). DDT is stored in the body fat and is excreted in the milk of dogs, rats, goats and cattle (15, 16).

Following an initial peak, excretion of DDT in the urine reaches a plateau and continues thereafter at a slow rate (18, 25); thus cumulative poisoning with DDT can and undoubtedly does occur with ease. DDT is demonstrable in the blood, bile, liver, kidney and central nervous system, as well as in the urine, in both acute and chronic poisoning (17), despite imperfect absorption. In cattle, eating of fodder contaminated with DDT residues in very small amounts, leads to storage in the muscles in amounts chemically detectable five weeks after discontinuing ingestion of DDT (14). Therefore, in addition to direct exposure to DDT powders, sprays and aerosols, cumulative poisoning in human beings is possible from ingestion of meat, milk, butter and other foods contaminated with traces of DDT.

Based partly on the military use of DDT, partly on acute studies on a small number of healthy adult volunteers and on limited observations of workers handling DDT, the misapprehension is widely current that DDT is lethal only to insects and is completely safe in all its forms for almost any insecticidal use by human beings. As a source of accurate toxicologic data, the military field experience with DDT leaves much indeed to be desired. Clinical syndromes of the type here described are hardly treated with sympathetic attention when occurring among soldiers in wartime. Questioning of returned veterans reveals that these reactions actually occurred frequently among soldiers exposed to DDT, but were invariably attributed to other causes. Unfortunately, the areas in which the heaviest treatment with DDT was required, are also the areas in which enteric infections especially are highly endemic.

This leaves then the investigations on human volunteers. Altogether comprehensive reports on five adult male volunteers were found in the literature; these volunteers were exposed to cutaneous absorption and ingestion of DDT solutions and inhalation of DDT aerosols. Of these five, three were investigated in Britain and two in the United States. In one case reported by Wigglesworth (1) brief application of

* Needless to say, findings related to the nervous system, and muscular spasm and weakness in severe acute affections of this type, have led to confusion with such entities as meningitis and poliomyelitis.

a solution of DDT in acetone to the skin, led to heaviness and aching of limbs and weakness of legs, "extreme nervous tension" and anxiety, insomnia and involuntary tremors of the whole body; anemia, leucocytosis and temporary rise in blood calcium occurred. Bed rest was required owing to pain in the extremities. The subject was away from work for 10 weeks and at the end of a year recovery was not yet complete.

Case (2) reports his own experience and that of a colleague, who exposed themselves to cutaneous absorption by direct contact with walls covered with a water-soluble paint containing two per cent of DDT and subsequently treated with a thin film of oil to simulate service conditions in the navy:

"The tiredness, heaviness, and aching of the limbs were very real things. and the mental state also was most distressing. Not only was a state of extreme irritability present, but also both subjects had a great distaste for work of any sort and a feeling of mental incompetence in tackling the simplest mental task . . . The joint pains were quite violent at times . . . subject A. I. was so prostrated he had to take to his bed for a day."

Other findings were increase in erythrocyte destruction, decrease in mean corpuscular hemoglobin, increase in reticulocytes, diminution in granulocytes accompanied by appearance of immature leukocytes, appearance of indican in the urine, diminution of some reflexes, and in one of the subjects, patchy anesthesia of the skin, slight impariment of hearing and transitory yellow vision, and muscular fibrillation. Recovery required from four to five weeks.

The American subjects were made of sterner stuff, for extensive inhalation of DDT aerosol (and in one of the subjects, subsequent ingestion of an oil solution of DDT), according to Neal, von Oettingen and their collaborators (26, 27), led to no significant untoward results. But even in these subjects diminution in hemoglobin from 19 to 15.5 gm. per 100 cc. occurred in one and a decrease of from 15 to 13.5 gm. in the other. Temporary irritation of the conjunctivae and respiratory tract, clumsiness and forgetfulness also occurred but these were attributed mainly to the vehicle in which DDT was dissolved. One of these subjects, as already indicated, twice subsequently ingested solutions of DDT in olive oil without ill effect (25). Yet Thoungh (7) has reported 27 cases of acute gastroenteritis with vomiting, diarrhea, giddiness and bradycardia following ingestion of rice accidentally contaminated with DDT powder, a form in which it is claimed to be less readily absorbed.

A survey of the literature reveals at least 46 known cases of DDT poisoning in human beings (1 to 12 to 28 to 30 to 32). The actual total is undoubtedly larger but indefiniteness in some of the reports does not permit of an accurate estimate. Sources of the DDT varied from actual ingestion of lethal quantities in solution, to exposure to DDT spray and aerosol, DDT paint and DDT residues on food. Six of the reported cases are known to have been fatal. The course of some of the other cases is not reported beyond the initial attack. In this investigation another fatal case undoubtedly due to DDT came to light. A young man who handled a large amount of DDT used mainly for dusting cattle, developed an intractable and rapidly fatal hemorrhagic gastroenteritis and hepatitis. The condition was attributed to an infection of unknown origin.

To anyone with even a rudimentary knowledge of toxicology, it exceeds all limits of credibility that a compound lethal for insects, fish, birds, chickens, rats, guinea pigs, rabbits, dogs, cats, goats, sheep, horses, cattle and monkeys would be nontoxic for human beings. The claims made by various investigators that DDT is safe for human beings were of course based on the assumption that the amounts to which persons would be exposed would not exceed the then known limits of tolerance. These limits did not take into consideration sensitization phenomena† or the tremendously wide variation in susceptibility to such toxic agents in the general population. Most of the exposed subjects examined have been healthy male adults, qualifications possessed by only a portion of the total population. But even the proposed safe limits have been exceeded.

Cameron and Burgess (33), for instance, considered solutions not to exceed 0.5 per cent of DDT safe for human use and pointed out that higher concentrations would be dangerous. Yet not only do the commercial preparations on the American market range mainly from three to 10 per cent, but they have been released for indiscriminate use by the general public, who in turn have been subjected to a barrage of dangerous misinformation on the subject. Even the 0.5 per cent solution advocated by Cameron and Burgess cannot be used safely by untrained persons, since even this concentration may be lethal to animals (34) and would undoubtedly be at least toxic to human beings.

Among the studies on the toxicology of DDT, two are of especial interest. Riker and his associates (35) and Jandorf, Sarrett and Bodansky (36) have both shown that DDT increases the oxygen consumption of body tissues. There is an increase in the metabolic rate of DDT-treated rats resembling somewhat that produced by the nitrophenols (35). (One cannot help but draw the analogy between the current use of DDT and the short-lived mania for dinitrophenol a decade ago. This substance too, on the basis of an impressive toxicologic investigation, was thought safe in limited dosage for human beings — until they began to develop cataract and other serious ill effects from its use). Riker and his collaborators (35) further pointed out the resemblance between some of the effects of DDT produced in animals and those of paraphenylenediamine and hydroquinone. No one nowa-

† One patient in the series reported in this paper, had been heavily exposed to DDT spray without apparent ill effect. A year later he was again exposed and promptly collapsed; he had nausea, vomiting, diarrhea, extreme muscular weakness, pain and aching in the limbs, etc. See also references 31 and 32.

days would even consider indiscriminate exposure of the public to these compounds.

An example of current impressions about the safety of DDT for the public appears in a recent issue of LIFE magazine. In a series of pictures DDT aerosols are shown being applied from an airplane and by ground equipment to the grounds of a resort, the inside of a cowbarn and a house and the like. Adults, children and cattle are shown engulfed by the aerosol, which is implied to be harmless, "The fog covers everything with a submicroscopic and stainless film of poison, lethal to insects but harmless to humans, animals and food." Indeed, a young lady is shown holding a sandwich and drinking a beverage in the midst of the aerosol cloud. Says LIFE "Unlike dust or spray the fog will not contaminate food."

In the course of inquiries made of numerous individuals, once DDT poisoning as a clue to the "virus X" syndrome became apparent, I was amazed to find that many persons use DDT solutions as freely as they would a detergent, and with no safeguards whatever to avoid personal contact. Additionally, serious illness and death in animals exposed to DDT, in every case attributed to infection, came to light. Two dogs dusted with DDT acquired severe "distemper" and had to be destroyed. In an apartment, within a few hours after the closets and their contents were intensively sprayed with DDT, a cocker spaniel began to vomit, developed convulsions and died the next day. Three young dogs kept in a kennel sprayed daily with DDT developed "distemper" and died, at a time when there had been no other cases of distemper among dogs in the neighborhood. (Hill and Robinson (3) reported death of two bull terriers sprayed with DDT). A siamese cat dusted with DDT developed convulsions in a few hours and died some days later with paralysis of the hind limbs. On a cattle ranch in which the animals were heavily dusted with DDT, a mysterious affection caused numerous deaths in these animals from a hemorrhagic, perforating enteritis, never before observed. In a midwestern farming community, numerous cases of an intractable hemorrhagic diarrhea ("black scours") have been occurring among cattle dusted or sprayed with DDT, kept in barns sprayed with this agent or fed with contaminated fodder. Many of these cattle have died. The "X disease" which ("although it started only recently") is reported to have caused serious losses among cattle in at least 26 states, bears a remarkable resemblance to the known effects of DDT poisoning.‡

There is no question that the DDT problem requires intensive further investigation. In the meantime, public health officials might well consider seriously the joint statement issued in 1945 by the U. S. Army and U. S. Public Health Service (37), While this statement is concerned primarily with mosquito control and does not adequately cover the possibility of toxic effects to human beings and domestic animals, the cautions there advised are relevant to all the uses of DDT:

"Successful use of the new insecticide DDT to combat insect-borne disease among our troops overseas has brought sudden renown and notoriety to this potent war-developed insect killer. Dramatic results of its large-scale use to control epidemics, and the spraying of DDT from aircraft, have fired public imagination and fostered the hasty conclusion that DDT is a complete solution to all our insect-borne disease problems. However, it must be remembered that DDT distributed over the countryside not only wipes out malaria-carrying mosquitoes but also may kill other insects, many of which are beneficial. Much still must be learned about the effect of DDT on the balance of nature, important to agriculture and wildlife, before general outdoor application of DDT can be safely employed in this country. It may be necessary to ignore these considerations in war areas where the health of our fighting men is at stake, but in the United States such considerations cannot be neglected. Extensive investigations are now being carried out by authorized agencies to determine the usefulness and possible hazards in the large-scale dissemination of DDT. Until more information has been obtained from such investigations and until it has been evaluated by all interested parties, plans to employ DDT indiscriminately for outdoor area control of insect disease vectors in this country are not to be encouraged."

SUMMARY

Evidence is presented that the new syndrome widely prevalent in the United States for more than two years and attributed to infection with a hypothetical "virus X," is in reality due to DDT poisoning.

‡ "X disease" of cattle is described as follows (Prairie Farmer 120:31, Aug. 28, 1948): "Young animals are most susceptible. Severely affected animals usually die. Pregnant animals frequently abort. It lasts from several weeks to about three months. Four to eight per cent of affected cattle die. Symptoms include a watery discharge from the eyes and nose, failing appetite, loss of condition, depression, and a gradual thickening of the skin. Sometimes diarrhea occurs in the late stages." Later reports indicate the incidence to be 31 per cent and the mortality 59 per cent.

REFERENCES

1. Wigglesworth, V. D.: A case of DDT poisoning in man. Brit. M. J., 1:517, April 14, 1945.
2. Case, R. A. M.: Toxic effects of DDT in man. ibid., 2: 842-845, Dec. 15, 1945.
3. Hill, K. R., and Robinson, G.: A fatal case of DDT poisoning in a child, with an account of two accidental deaths in dogs. ibid., 2:845-847, Dec. 15, 1945.
4. Mackerras, I. M., and West, R. F. K.: DDT poisoning in man. M. J. Australia, 1:400-401, March 23, 1946.
5. Smith, M. I.: Accidental ingestion of DDT, with a note on its metabolism in man. J. A. M. A., 131:519-520, June 8, 1946.
6. Biden-Steele, K., and Stuckey, R. E.: Poisoning by DDT emulsion; report of a fatal case. Lancet, 2:235-236, Aug. 17, 1946.
7. Thoungh, U. C.: Poisonous effects of DDT on humans. Indian M. Gaz., 81:432, Oct., 1946.
8. Wright, C. S., Doan, C. A., and Haynie, H. C.: Agranu-

locytosis occuring after exposure to DDT pyrethrum aerosol bomb. Am. J. Med., 1:562-567, Nov., 1946
9. Hill, K. R., and Damiani, C. R.: Death following exposure to DDT. Report of a case. New Eng. J. Med., 235: 897-899, Dec. 19, 1946.
10. Garett, R. M.: Toxicity of DDT for man. Alabama St. M. A. J., 17:74, Aug., 1947.
11. Smith, N. J.: Death following accidental ingestion of DDT. J. A. M. A., 136:469-471, Feb. 14, 1948.
12. Deederer, C.: DDT toxicity. M. Rec. 161:216-220, April, 1948.
13. Sollmann, T.: Manual of Pharmacology, 7th ed., Philadelphia; W. B. Saunders and Co., 1948.
14. Carter, R. H., Hubanks, P. E., et al.: Effect of cooking on the DDT content of beef. Science, 107:347, April 2, 1948.
15. Woodard, G., Ofner, Ruth B., and Montgomery, C. M.: Accumulation of DDT in the body fat and its appearance in the milk of dogs. Science, 102:177-178, Aug. 17, 1945.
16. Telford, H. S., and Guthrie, J. E.: Transmission of the toxicity of DDT through the milk of white rats and goats, ibid., 102:647, Dec. 21, 1945.
17. Smith, M. I., and Stohlman, E. F.: Pharmacologic action of 2, 2 bis (p-Chlorophenyl) 1, 1, 1-Trichloroethane and its estimation in the tissues and body fluids. Pub. Health Rep., 59:984, July 28, 1944.
18. Smith, M. I., and Stohlman, E. F.: Further studies on the pharmacologic action of DDT. ibid., 60:289, March 16, 1945.
19. Fitzhugh, O. G., and Nelson, A. A.: The chronic oral toxicity of DDT. J. Pharmacol. & Exper. Therap., 89:18-30, Jan., 1947.
20. Sarrett, H. P., and Jandorf, B. J.: Effects of chronic DDT intoxication in rats on lipids and other constituents of liver. ibid., 91:340-344, Dec., 1947.
21. West and Campbell: DDT, the synthetic insecticide. London: Chapman and Hall, Ltd., 1946 (review).
22. Lillie, R. D., Smith, M. I., and Stohlman, E. F.: Pathologic action of DDT and certain of its analogs and derivatives. Arch. Path., 43:127-142, Feb., 1947.
23. Crescitelli, F., and Gillman, A.: Electrical manifestations of cerebellum and cerebral cortex following DDT administration to cats and monkeys. Am. J. Physiol., 147:127-137, Sept., 1946.
24. Haymaker, W., Ginzler, A. M., and Ferguson, R. L.: Toxic effects of prolonged ingestion of DDT on dogs, with special reference to lesions in brain. Am. J. M. Sc., 212:423, Oct., 1946.
25. Neal, P. A., Sweeney, T. R., Spicer, S. S., and von Oettingen, W. F.: The excretion of DDT in man, together with clinical observations. Pub. Health Rep., 61: 403, March 22, 1946.
26. Neal, P. A., von Oettingen, W. F., Smith, W. W., et al.: Toxicology and potential dangers of aerosols, mists and dusting powders containing DDT. Pub. Health Rep., Suppl. 177, 1944.
27. Neal, P. A., von Oettingen, W. F., Dunn, R. C., and Sharpless, N. E.: Toxicology and potential dangers of aerosols and residues from aerosols containing 3 per cent of DDT. Second Report, ibid., Suppl. 183, 1945.
28. Niedelman, M. L.: Contact dermatitis due to DDT. Occup. Med., 1:391-395, April, 1946.
29. Strycker, G. V., and Godfroy, B.: Dermatitis resulting from exposure to DDT. J. Missouri St. M. A., 43: 384-386, June, 1946.
30. Gordon, I.: The occupational hazard of DDT spraying. Brit. J. Indust. Med., 3:245-249, Oct., 1946.
31. Dunn, J. E., Dunn, R. C., and Smith, B. S.: Skin sensitizing properties of DDT for guinea pig. Pub. Health Rep., 61:1614-1620, Nov. 8, 1946.
32. Leider, Morris: Allergenic eczematous contact-type dermatitis caused by DDT. J. Invest. Dermatol., 8: 125-126, March, 1947.
33. Cameron, G. R., and Burgess, F.: The toxicity of DDT. Brit. M. J., 1:865-871, June 23, 1945.
34. Taylor, E. L.: Danger of inunction with DDT. Lancet, 2:320, Sept. 8, 1945.
35. Riker, W. F., Jr., Huebner, Virginia, R., Raska, S. B., and Cattell, McKeen.: Studies on DDT, effects on oxidative metabolism. J. Pharmacol. and Exper. Therap., 88:327-332, Dec., 1946.
36. Jandorf, B. J., Sarrett, H. P., and Bodansky, Oscar: Effect of oral administration of DDT on metabolism of glucose and pyruvic acid in rat tissues. ibid., pp. 333-337.
37. Use of DDT for mosquito control in the United States. A joint statement of policy by the U. S. Army and the U. S. Public Health Service. Pub. Health Rep., 60:469, April 27, 1945.

Surgical Considerations of Choledocholithiasis

By

JULIAN A. STERLING, M.D.

PHILADELPHIA, PA.

SURGICAL EXPLORATION of the common bile duct has increased in frequency during the past ten years. There are several reasons for this. First, patients with cholelithiasis and without jaundice may have stones in the common duct (1). Such calculi may be first observed at operation. Second, there is a lower morbidity today in patients operated upon for common duct obstruction (2). This is due almost entirely to improved preparation of each patient and the realization by the gastroenterologist that cholelithiasis requires surgical therapy. Third, technical advance has placed tumors of the pancreas and in the region of the papilla of the bile duct within the scope of surgical attack (3).

DIAGNOSIS

Early diagnosis of common duct disease is a most important aspect in surgical therapy. It may be difficult to differentiate intra- from extra-hepatic jaundice, particularly if the icterus is of several weeks duration (1). It is of significance that jaundice may be found in fifty per cent of patients with common duct stone. On the other hand, exploration of the common duct reveals that fifty per cent of jaundiced patients have a stone as the cause for the jaundice (4).

In addition, a tumor less than one centimeter in diameter which is located near the termination of

From the Department of Pathology and the Surgical Service of the Jewish Hospital, Phila., Pa.

(Read before the Northern Branch of the County Medical Society, Philadelphia, March 22, 1948).

Submitted July 2, 1948.