Section I

GENERAL INFORMATION

CHAPTER 1

Introduction

This fifth edition of *Recognition and Management of Pesticide Poisonings* is an update and expansion of the 1989 fourth edition. The Office of Pesticide Programs of the United States Environmental Protection Agency has sponsored the series since 1973. The purpose of the manual is to provide health professionals with recently available information on the health hazards of pesticides currently in use, and current consensus recommendations for management of poisonings and injuries caused by them.

Pesticide poisoning is a commonly under-diagnosed illness in America today. Despite recommendations by the Institute of Medicine and others urging the integration of environmental medicine into medical education, health care providers generally receive a very limited amount of training in occupational and environmental health, and in pesticide-related illnesses, in particular.[1] The updating of this manual is part of a larger initiative of the U.S. Environmental Protection Agency, in conjunction with numerous federal agencies, associations of health professionals, and related organizations to help health care providers become better aware, educated, and trained in the area of pesticide-related health concerns. This larger initiative, entitled Pesticides and National Strategies for Health Care Providers, was launched in April 1998.

As with previous updates, this new edition incorporates new pesticide products that are not necessarily widely known among health professionals. The accumulated "use experience" of formulators, applicators, and field workers provides an expanding basis for judging safety and identifying the environmental and workplace hazards of old and new pesticides. Major episodes of adverse health effects reported in medical and scientific periodicals have been taken into account. This literature also contributes importantly to improved understanding of toxic mechanisms. Clinical toxicology is a dynamic field of medicine; new treatment methods are developed regularly, and the effectiveness of old as well as new modalities is subject to constant critical review.

There is general agreement that *prevention* of pesticide poisoning remains a much surer path to safety and health than reliance on treatment. In addition to the inherent toxicity of pesticides, none of the medical procedures or drugs used in treating poisonings is risk-free. In fact, many antidotes are toxic in their own right, and such apparently simple procedures as gastric intubation incur substantial risk. The clinical toxicologist must often weigh the hazards of various courses of action—sometimes including no treatment at all—against the risks of various interventions, such as gastric emptying, catharsis, administration

of intravenous fluids, or administration of an antidote, if available. Clinical management decisions have to be made promptly and, as often as not, on the basis of limited scientific and medical information. The complex circumstances of human poisonings rarely allow precise comparisons of alternative management. In no sense, then, are the treatment recommendations in this book infallible guides to successful outcomes. They are no more than consensus judgments of the best available clinical management options.

This manual deals almost entirely with short-term (acute) harmful effects of pesticides. Although obviously important, the subject of chronic effects is too complex to deal with exhaustively in a manual designed as guidance for emergency management. Nonetheless, appropriate treatment of serious exposures to pesticides represents an important step in avoiding chronic as well as acute disease.

The pesticides and commercial products mentioned in this manual do not represent the universe of pesticide products in existence. They were selected based on frequency of use and exposure, severity of toxicity, and prior experience with acute poisonings. Products are discussed in this manual that have been discontinued or whose U.S. pesticide registration has been revoked but are judged to still be of risk due to use elsewhere or where there is a probability of residual stocks. Agents long out of use in the U.S. and elsewhere were not included in the manual.

The amount of pesticide absorbed is a critical factor in making treatment decisions, and estimation of dosage in many circumstances of pesticide exposure remains difficult. The terms "small amount" and "large amount" used in this book are obviously ambiguous, but the quality of exposure information obtained rarely justifies more specific terminology.

Sometimes the circumstances of exposure are a rough guide to the amount absorbed. Exposure to spray drift properly diluted for field application is not likely to convey a large dose unless exposure has been prolonged. Spills of concentrated technical material onto the skin or clothing may well represent a large dose of pesticide unless the contamination is promptly removed. Brief dermal exposure to foliage residues of cholinesterase-inhibiting pesticides is not likely to lead to poisoning, but prolonged exposures may well do so. Suicidal ingestions almost always involve "large amounts," requiring the most aggressive management. Except in children, accidental pesticide ingestions are likely to be spat out or vomited. Ingestions of pesticides by children are the most difficult to evaluate. The therapist usually must base clinical management decisions on "worst case" assumptions of dosage. Childhood poisonings are still further complicated by the greater vulnerability of the very young, not only to pesticides themselves, but also to drugs and treatment procedures. The nature of neurological development in children entails an additional level of risk that is not present in adults. Some adult groups such as farmwrokers with poor nutrition and high exposure may also be at increased risk.

Key Principles

General methods of managing pesticide poisonings are presented in Chapter 2 and reflect a broad base of clinical experience. The following key points deserve emphasis. The need to protect the airway from aspiration of vomitus cannot be overstated. Death has occasionally resulted from this complication, even following ingestions of substances having relatively low toxic potential. In poisonings by agents that depress central nervous system function or cause convulsions, early placement of a cuffed endotracheal tube (even when this requires light general anesthesia) may be life saving. Maintenance of adequate pulmonary gas exchange is another essential element of poisoning management that deserves constant reemphasis.

Gastric intubation, with aspiration and lavage, remains a useful method for removing poisons from the stomach shortly after they have been swallowed, but the time after ingestion during which lavage is likely to be beneficial is shorter than many clinical toxicologists have thought. Rarely are significant amounts of swallowed toxicants recovered more than 1-2 hours after ingestion, and, in many instances, the bulk of swallowed material passes into the duodenum and beyond in 15-30 minutes. In addition, the majority of controlled studies evaluating the effectiveness of gastric emptying procedures are done for ingestions of solid material (pills) rather than liquids.

Full advantage should be taken of new highly adsorbent charcoals that are effective in binding some pesticides in the gut. Unfortunately, charcoal does not adsorb all pesticides, and its efficiency against many of them is not known. In poisonings caused by large intakes of pesticide, hemodialysis and hemoperfusion over adsorbents continue to be tested as methods for reducing body burdens. Against some toxicants, these procedures appear valuable. Overall effectiveness appears to depend not only on efficiency of clearance from the blood, but also on the mobility of toxicant already distributed to tissues before the extracorporeal blood-purification procedure is started. The volume of distribution and avidity of tissue binding are important considerations in making such decisions. The critical determinant of success in using these systems may well be the speed with which they can be put into operation before tissue-damaging stores of toxicant have accumulated.

There remains a need for systematic reporting of pesticide poisonings to a central agency so that accurate statistics describing the frequency and circumstances of poisoning can be compiled, and efforts to limit these occurrences can be properly directed. In some countries there has been an increase in the use of pesticides as instruments of suicide and even homicide. Producers are now devoting considerable effort to modifying formulation and packaging to deter these misuses. This work is important because suicidal ingestions are often the most difficult pesticide poisonings to treat successfully.

Common Pesticide Poisonings

The pesticides most often implicated in poisonings, injuries, and illnesses, according to 1996 data from the American Association of Poison Control Center's Toxic Exposure Surveillance System, are listed below.

The list is based on symptomatic cases classified as minor, moderate, major, or fatal outcome for unintentional cases involving a single product. Numbers of cases are reported for both children under six years of age and for adults and older children. Suicide/homicide (intentional) cases have been excluded. Cases listed as organophosphates (and the other categories as well) may also include other insecticides such as carbamates and organochlorines in a single product.

PESTICIDES MOST OFTEN IMPLICATED IN SYMPTOMATIC ILLNESSES, 1996

Rank	Pesticide or Pesticide Class	Child < 6 years	Adults 6-19 yrs.	Total*
1	Organophosphates	700	3274	4002
2	Pyrethrins and pyrethroids**	1100	2850	3950
3	Pine oil disinfectants	1336	903	2246
4	Hypochlorite disinfectants	808	1291	2109
5	Insect repellents	1081	997	2086
6	Phenol disinfectants	630	405	1040
7	Carbamate insecticides	202	817	1030
8	Organochlorine insecticides	229	454	685
9	Phenoxy herbicides	63	387	453
10	Anticoagulant rodenticides	176	33	209
	All Other Pesticides	954	3604	4623
	Total all pesticides/disinfectants	7279	15,015	22,433

* Totals include a small number of cases with unknown age.
** Rough estimate: includes some veterinary products not classified by chemical type.

Source: American Association of Poison Control Centers, Toxic Exposure Surveillance System, 1996 data.

Approximately 90% of symptomatic cases involve only minor symptoms of the type that could typically be treated at home with dilution or just observation. However, seven of the top ten categories listed in the table above (organophosphates, pyrethrins/pyrethroids, hypochlorite disinfectants, carbamates, organochlorines, phenoxy herbicides, and anticoagulant rodenticides) are much more likely to require medical attention.

This list cannot be considered representative of all symptomatic poisonings because it only shows cases reported to Poison Control Centers. However, it does give a sense of the relative frequency and risk of poisoning from various agents or classes of agents. The relative frequency of cases generally reflects how widely a product is used in the environment. For example, a number of disinfectants occur in the top ten partly because they are far more commonly found in the home and work environment than other pesticides (see also the table of occupational cases

below). Denominator information on the population at risk (numbers exposed) would be needed to better understand the relative risk of different pesticides. However, the main purpose of these tables is to give physicians a sense of what types of cases they are most likely to see in their practice.

Although suicide cases make up roughly 3% of pesticide-related calls to Poison Control Centers, they may account for nearly 10% of the cases seen in a health care facility. The leading types of products involved in suicidal cases include anticoagulant rodenticides (20% of total suicide attempts), pine oil disinfectants (14%), organophosphates (11%), pyrethrins/pyrethroids (6%), unknown rodenticides (5%), carbamate insecticides (4%), and phenol disinfectants (3%).

CALIFORNIA OCCUPATIONAL ILLNESSES LIKELY DUE TO PESTICIDES, 1991-1995

Rank	Pesticide	Systemic	Topical*	Total
1	Sodium hypochlorite	167	858	1025
2	Quaternary ammonia	9	348	357
3	Chlorine	112	124	236
4	Glutaraldehyde	38	118	156
5	Chlorpyrifos	113	39	152
6	Sulfur	48	69	117
7	Glyphosate	9	94	103
8	Propargite	3	96	99
9	Metam sodium**	64	33	97
10	Cyanuric acid	14	76	90
	All Other	1149	1089	2238
	Total all pesticides/disinfectants	1726	2944	4670

* Topical includes skin, eye, and respiratory effects.
** Train derailment led to a cluster of cases due to metam sodium in 1991.

Source: Louise Mehler, M.S., California Pesticide Illness Surveillance Program, California Environmental Protection Agency.

Poison Control Centers are best at capturing pesticide exposures which occur in residential environments. However, occupational exposures are not as well covered. California's Pesticide Illness Surveillance Program is generally regarded as the best in the country. The table above presents the number of occupationally-related cases in California reported from 1991 through 1995 where a pesticide was considered a probable or definite cause of the resulting illness. Pesticide combinations, where the primary pesticide responsible for the illness could not be identified, are not included in this table. Among persons who encounter pesticides in the course of their occupational activities, dermal and eye injuries, rather than systemic poisonings, are more common. Systemic poisonings, however, are likely to be more severe.

Format of this Manual

An effort has been made to format this book for quick reference by thorough indexing and minimal references to other pages or chapters. However, many different agents commonly require similar procedures in treating poisonings and it is not practical to repeat these protocols in every chapter. General principles for management of pesticide poisoning, including skin and eye decontamination, gastrointestinal decontamination, and control of convulsions are considered in Chapter 2, General Principles. These principles are referenced throughout.

Changes in this reformatted edition include: tabular listings of Commercial Products in each chapter, the addition of a new chapter on Disinfectants (Chapter 19), and the addition of a chapter on Environmental and Occupational History (Chapter 3), which places pesticide poisonings in the context of other environmental and occupational exposures, provides questionnaires designed to elicit exposure information, discusses resources available to the practitioner, and provides a list of governmental and non-government contacts and Web sites for more information. In addition, each chapter is referenced to key references in readily accessible current literature. Most references were selected as primary references in peer review journals, although some review papers are also included.

The contents of this book have been derived from many sources: published texts, current medical, toxicological, and pesticide product literature, and direct communications with experts in clinical toxicology and pesticide toxicology and environmental and occupational health specialists. A list of the major text sources follows this introduction.

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