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Tools for Clinical Toxicology on the World Wide Web: Review and Scenario

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ABSTRACT

Clinical toxicologists are entrusted with the health and safety of humans and animals exposed to toxic substances. To do their jobs well they need a solid knowledge of toxicological principles, an ability to handle emergent situations, a “bedside” manner that results in a good rapport with patients, and the ability to access current and accurate information in order to properly care for the afflicted. An information armamentarium that is increasingly digital and Web-based is becoming a necessity. This article reviews Web resources that can assist the toxicologist. A case scenario is presented to provide a practical perspective to the information tools outlined.

Key Words: Information; Computers; Web; Toxicology

INTRODUCTION

Of the many branches of toxicology which can be said to have a bearing on the health and welfare of people, none are as directly pertinent as clinical and medical toxicology, which deal with diagnosing and treating humans exposed to drugs and other chemicals, as well as biological toxins. Veterinary toxicology, closely allied with clinical toxicology, uses many similar investigative processes to explore poisoning in animals.

The history of clinical toxicology can very well claim to be the history of toxicology itself. Early man’s
exploration of his surroundings was fraught with danger, some of it no different than what we face today. Although anthropogenic pollution, industrial chemicals, and side effects of synthetic drugs were not of concern, poisoning by food, animals (poisonous and venomous), and non-anthropogenic pollution such as volcanic ash—certainly taught people to be on high alert. Trial and error over many generations helped man determine which berries were safe and which were dangerous, which mushrooms could be consumed and which should be avoided, which snakes were harmless and which were injurious. And in some instances, perhaps with the advent of fermented beverages, although probably much earlier, humans instinctively grasped “the dose makes the poison” principle prior to its famous articulation by Paracelsus. Humans learned what would sustain them and they would seek out this nourishment and share it with their friends. With equal facility, they learned collectively and via their shamans what was harmful. Such substances they would avoid themselves (unless they had suicidal tendencies) and impose instead upon their enemies. Following early man’s lessons with hazardous substances came experimentation with potions as a way to ameliorate symptoms or affect a cure.

Data from observations and experimentation have always served as the backbone for scientific knowledge and its applications. Although this has not changed over time, we now have at our fingertips electronic tools to enable us to better generate, collect, organize, and access this data. In some respects, perhaps with the advent of fermented beverages, although probably much earlier, humans instinctively grasped “the dose makes the poison” principle prior to its famous articulation by Paracelsus. Humans learned what would sustain them and they would seek out this nourishment and share it with their friends. With equal facility, they learned collectively and via their shamans what was harmful. Such substances they would avoid themselves (unless they had suicidal tendencies) and impose instead upon their enemies. Following early man’s lessons with hazardous substances came experimentation with potions as a way to ameliorate symptoms or affect a cure.

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**THE PROFESSION**

Clinical toxicology has benefited from observation, experimentation, and research. Indeed medical toxicology is a certified medical specialty and a sub-board of the American Board of Emergency Medicine, the American Board of Preventive Medicine, and the American Board of Pediatrics. These sub-boards took the place of the former American Board of Medical Toxicology and certify physicians in the specialty of medical toxicology. The American College of Medical Toxicology (http://www.acmt.net/) was formed as a professional society that offers full membership to physicians who are boarded in medical toxicology. Certification procedures for nonphysician clinical toxicologists are offered through the American Board of Applied Toxicology (http://www.clin tox.org/Abat). Professional toxicology societies cover the field’s many facets and are widespread.[3,4]

American Academy of Clinical Toxicology (AACT) (http://www.aactox.org/)—founded in 1968, its membership of scientists and clinicians promotes the study of health effects of poisons on humans and other animals. AACT’s annual meeting, the North American Congress of Clinical Toxicology, is co-sponsored by the American Association of Poison Control Centers (AAPCC), the Canadian Association of Poison Control Centers, the European Association of Poison Control Centers, the European Association of Poison Centres and Clinical Toxicologists, and the American College of Medical Toxicology.

American Association of Poison Control Centers (http://www.aapcc.org/)—AAPCC is a nationwide organization of poison control centers and interested individuals. Though not a professional association, this group has a strong affiliation with the AACT. The annual statistical compendiums of poisoning surveillance, the Toxic Exposure Surveillance System (TESS) reports, are available at their Web site.

Other groups—clinical toxicologists may also be members of related groups such as the Society of Toxicology (http://www.toxicology.org), which focuses more on basic research, and related medical organizations such as the American College of Occupational and Environmental Medicine (http://www.acoem.org/). On an international level, the European Association of Poison Centres and Clinical Toxicologists (http://www.eapct.org/) is concerned with advancing knowledge in the diagnosis and treatment of poisoning, and it in turn is a member society of the International Union of Toxicology (http://www.toxicology.org/iutox/), as is the AACT. It should be noted that for many IUTOX national member societies, there is no distinction made between clinical and nonclinical toxicology and, for the countries they represent, particularly in the developing world, toxicology is often synonymous with clinical toxicology. Many of the tools and techniques of clinical toxicologists are also employed in forensic toxicology, which utilizes toxicology in the service of the law. The Society of Forensic Toxicologists (http://www.soft-tox.org/) is the main U.S. group representing the profession. The International Association of Forensic Toxicologists
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(http://www.tiaft.org/) is its global equivalent. The American Board of Veterinary Toxicology (http://www.abvt.org) consists of veterinarians specially trained in the knowledge of toxicological hazards to pets, livestock, and wildlife. The Society of Toxicologic Pathologists (http://www.toxpath.org) is the primary organization devoted to professionals working in this discipline. The aim of the International Society of Toxicology (http://bio.ijs.si/ist.htm) is to advance knowledge on the properties of toxins and antitoxins.

Other disciplines—clinical toxicology plays a role in many other disciplines. For instance the broad field of occupational safety and health, while not the focus of this article, contains a substantial toxicological component and uses many of the same tools discussed here. Among the many useful resources for professionals in this subject are the American Industrial Hygiene Association (http://www.aiha.org), the National Institute for Occupational Safety and Health (http://www.cdc.gov/niosh/homepage.html), and the Association of Occupational and Environmental Clinics (http://www.aoec.org/).

TOXNET AND OTHER NATIONAL LIBRARY OF MEDICINE RESOURCES

The National Library of Medicine (NLM) through its Toxicology and Environmental Health Information Program (TEHIP) has long been a leader and innovator in offering computerized access to toxicological information. Its primary toxicological database repository is the TOXNET system (http://toxnet.nlm.nih.gov). TOXNET encompasses databases of summary toxicological information, technical literature references, chemical nomenclature, and toxic releases.[5]

Hazardous Substances Data Bank (HSDB)

Containing over 4500 chemical records and some 150 data fields, HSDB undergoes a high level of scrutiny via a peer-reviewed Scientific Review Panel of distinguished toxicologists, physicians, industrial hygienists, environmental professionals, and other scientists. Of particular interest to clinical toxicologists are the human health effects data and emergency medical treatment (from Micromedex’s Poisindex database). Also covered extensively are synonyms, manufacturing and use information, chemical and physical properties, safety and handling, animal (nonhuman) toxicity data, pharmacokinetics, pharmacology, environmental fate and exposure potential, exposure standards and regulations, and monitoring and analysis. Data is drawn from several hundred books, technical reports, journal literature, and other computer databases.

Toxline

With over 3 million references, TOXLINE is the world’s premiere database devoted to bibliographic citations to the toxicology scientific literature. TOXLINE is composed of two components—TOXLINE Core and TOXLINE Special. Both of these are accessible from TOXNET’s TOXLINE interface. The “Core” component links to NLM’s MEDLINE, a vast bibliographic database covering the broad biomedical literature, and searches across a substantial subset of citations related to toxicology. TOXLINE Special references are drawn from a variety of journal and technical report databases, some of which are regularly updated while others carry archival but still important information.

TOXLINE Technical Reports and Research Projects

Federal Research in Progress
Toxicology Document and Data Depository
Toxicology Research Projects
Toxic Substances Control Act Test Submissions

TOXLINE Special Journal and Other Research Literature

Developmental and Reproductive Toxicology
International Labour Office
Swedish National Chemicals Inspectorate

TOXLINE Archival Collections (No Longer Being Updated in TOXLINE)

Aneuploidy
Environmental Mutagen Information Center
Environmental Teratology Information Center
Epidemiology Information System
Hazardous Materials Technical Center
International Pharmaceutical Abstracts
NIOSHTIC
Pesticides Abstracts
Poisonous Plants Bibliography
Toxicological Aspects of Environmental Health

ChemIDplus

A good source for chemical nomenclature, identifying information and structures, ChemIDplus also offers links to other databases within and outside NLM with further information on the chemical searched. Its Superlist feature identifies regulatory lists on which ChemIDplus chemicals appear.

Other TEHIP Resources

Other TOXNET databases include the National Cancer Institute’s Chemical Carcinogenesis Research Information System (CCRIS) and the EPA’s Integrated Risk Information System (IRIS). The TEHIP Web site of toxicology and environmental health information (http://sis.nlm.nih.gov/Tox/ToxMain.html) offers access to more than just the TOXNET databases and chemical information. It includes the TOXTUTOR series of tutorials covering the basic principles of toxicology, news items, special topics, and publications such as database fact sheets and a glossary of terms used in toxicology, as well as access to DIRLINE (http://dirline.nlm.nih.gov/) a directory of thousands of health and science organizations. Special Topic reviews have been prepared in areas such as chemical warfare agents, biological warfare agents, and pesticides used in controlling the vector for the West Nile Virus. HazMap, an occupational medicine database, was released in the spring of 2002 and a database on consumer products is under development as are other tools geared to bringing toxicology and environmental health information to the public.

Also at NLM

As noted earlier, the TOXLINE Core portion of TOXNET is actually a MEDLINE subset. One can also search directly across all of MEDLINE at the PubMed site at http://pubmed.gov. MEDLINE itself carries vast amounts of material of clinical relevance.[6] Clinical research studies can be searched via ClinicalTrials.gov (http://clinicaltrials.gov), which includes a disease heading of Injuries, Poisonings, and Occupational Diseases. NLM has collected extensive links to consumer health information at its MEDLINEplus site (http://medlineplus.gov), which includes topics in the broad category of poisoning, toxicology, and environmental health. Finally, NLM has constructed a still evolving Gateway that will allow searching across all of its databases simultaneously (http://gateway.nlm.nih.gov/gw/Cmd).

MORE U.S. GOVERNMENT AGENCY RESOURCES

Agency for Toxic Substances and Disease Registry (ATSDR) (http://www.atsdr.cdc.gov)

A wide variety of databases covering specific chemicals and hazardous waste sites are available through the ATSDR. Toxicologists should be aware of the detailed chemical reports issued as part of the Toxicological Profiles series as well as TOXFAQs, which presents less technical summaries of these documents. The Profiles include such information as health effects, chemical and physical properties, production, import, use and disposal, potential for human exposure, analytical methods, and regulations and advisories. Toxicological Profiles (261) have been published or are under development as “finals” or “drafts for public comment.”

Environmental Protection Agency (EPA) (http://www.epa.gov)

EPA’s Web site is a vast resource for information on all manner of chemicals, including pesticides, in air, water, and soil.[7] A very few of its services to take note of are Envirofacts (http://www.epa.gov/enviro), IRIS (http://www.epa.gov/iris), and Toxics Release Inventory (http://www.epa.gov/tri). The EPA site is an invaluable source of environmental clinical information.

Food and Drug Administration (FDA) (http://www.fda.gov)

The FDA is the U.S. government agency regulating food, drugs, biologicals, veterinary products, and medical devices. Valuable information on their Web site includes New and Generic Drug Approvals, Major Drug Information Pages, Public Health Alerts, and Consumer and Over-the-Counter Drug Information. Its MedWatch (http://www.fda.gov/medwatch), a safety information and adverse event-reporting program, provides information on safety issues involving medical products including prescription and over-the-counter drugs, biologics, medical and radiation-emitting devices, and special nutritional supplements.
National Toxicology Program (NTP) (http://ntp-server.niehs.nih.gov)

NTP offers a broad range of databases through a Web-searchable interface. These include Health and Safety Information on over 2000 chemicals studies by the NTP and the NTP Testing Information and Study Results. The latter provides information in such areas as the status of individual agents being studied by the NTP, management status reports, long-term carcinogenicity bioassays, and short-term tests.

OTHER RESOURCES

Micromedex (http://www.micromedex.com)

Micromedex, since its inception in 1974 with the POISINDEX System, has been a major player in the field of clinical toxicology. It operates a fee-based service providing access to POISINDEX, TOXPOINTS, TOMES, and REPRORISK, although many of its other products are also useful for clinical toxicologists and poison control centers.

POISINDEX and TOXPOINTS

POISINDEX identifies ingredients for hundreds of thousands of commercial, pharmaceutical, and biological substances. Clinical effects, range of toxicity and treatment protocols are part of the information included in management documents provided for these substances. Briefer overviews of toxicity, signs and symptoms, and treatment are provided by TOXPOINTS. The information in its more than 150 documents is drawn from POISINDEX data.

ChemKnowledge

Formerly known as TOMESplus, the ChemKnowledge system includes an array of medical, environmental, and hazard databases (which can be searched simultaneously) to assist in the safe management of chemicals. These databases are:

MEDITEXT® Medical Managements
HAZARDTEXT® Hazard Managements
INFOTEXT® Documents
HSDB
CHRIS (Chemical Hazard Response Information System)

OHM/TADS (Oil and Hazardous Materials/Technical Assistance Data System)

IRIS
RTECS® (Registry of Toxic Effects of Chemical Substances)
NIOSH (National Institute for Occupational Safety & Health) Pocket Guide
New Jersey Hazardous Substance Fact Sheets
2000 Emergency Response Guidebook
REPRORISK System (see below)

REPRORISK

Another service of MICROMEDEX is REPRORISK. The system helps professionals evaluate reproductive risks of drugs, chemicals, and physical and environmental agents on males, females, and developing fetuses. It includes the REPROTEXT® System, the REPROTOX® System, Shepard’s Catalog of Teratogenic Agents, and TERIS Teratogen Information System. Among the topics covered in REPRORISK are general toxicity, fertility, genetic influences, and teratogenic agents. The REPROTEXT System, for example, helps set risk reducing priorities by combining hazard rankings with exposure estimates.

INCHEM (http://www.inchem.org)

Produced by the International Programme on Chemical Safety (IPCS), INCHEM consolidates information from various international bodies with the goal of assisting in the sound management of chemicals. Their databases include:

CIS Chemical Information (ILO/CIS)
Concise International Chemical Assessment Document (CICADS)
Environmental Health Criteria (EHC) monographs
Health and Safety Guides (HSGs)
International Agency for Research on Cancer (IARC)—Summaries & Evaluations
International Chemical Safety Cards (ICSCs)
IPCS/CEC Evaluation of Antidotes Series
JECFA (Joint Expert Committee on Food Additives)—Monographs and Evaluations
JMPR (Joint Meeting on Pesticide Residues)—monographs and evaluations
Pesticide Data Sheets (PDSs) Poisons Information Monographs (PIMs)
Screening Information Data Set (SIDS) for High Production Volume Chemicals

INCHEM databases serve a variety of purposes and audiences, and differ in detail and scope. EHC Monographs, for example, offer comprehensive data for scientists and administrators. They review and examine physical/chemical properties and analytical methods, sources of environmental and industrial exposure and environmental transport, chemobiokinetics and metabolism including absorption, distribution, transformation, and elimination; short and long term effects on animals (carcinogenicity, mutagenicity, and teratogenicity); and finally, an evaluation of risks for human health and the effects on the environment. ICSCs, on the other hand, briefly summarize essential health and safety information on chemical substances in a tabular format and are particularly relevant to workplace exposures. All of the INCHEM databases are free and provide chemical safety information that can assist the clinical toxicologist.

INTOX (http://www.intox.org)

IPCS is also the creator of the INTOX Data Management System and the INTOX Databank. The former is a poison information database management system, while the latter is a compilation of documents on poisons. Information is provided on industrial chemicals, pharmaceuticals, household products, agricultural chemicals, plant, fungal and animal toxins, and other agents responsible for poisoning. INTOX has also worked to systematize, standardize, and harmonize classifications, terms, and poisoning reporting formats. Thus, they have developed controlled vocabularies for classes of chemicals, animal and plant classes, product uses, and clinical effects. Finally, the INTOX Information Exchange is a mailing list type forum.

GENERAL CHEMICAL COMPENDIA

In addition to the sources discussed above, there are numerous other chemical compendia that include toxicity and safety information.

ChemFinder.com

ChemFinder.com (http://chemfinder.cambridgesoft.com/) is very much like a Web search engine restricted to chemicals. Enter a chemical name and you will find links to databases and other sources of information in areas such as Biochemistry, Health, MSDS’, Physical Properties, Regulations, Structures, and Usage. Also provided are physical property data and two-dimensional structures. The extensive list of sites indexed is separately available for viewing and each site name is hot-linked to its URL.

Material Safety Data Sheets (MSDS)

First mandated by the Occupational Safety and Health Administration’s Hazard Communication Standard, MSDS’ are generally brief documents, designed largely for workers but also useful for emergency personnel and others, although questions about the reliability of the data for health care have been posed. They contain some physical and chemical data and information on toxicity, first aid, precautions, cleanup and disposal, protective equipment and other aspects of safety and handling, and are of particular value in the case of a spill or other accident. Among the good compilations of information on and links to MSDS’ on the Web are: Where to Find Material Safety Data Sheets on the Internet (http://www.ilpi.com/msds/) and MSDS Search (http://www.msdssearch.com/).

Right-to-Know Hazardous Substance Fact Sheets (from the State of New Jersey)

These fact sheets (http://www.state.nj.us/health/eho/rtkweb/rtkhfs.htm) cover over 1300 chemicals and contain acute and chronic health hazards, identification, workplace exposure limits, medical tests, workplace controls and practices, personal protective equipment, handling and storage, questions and answers, definitions, and emergency response information for fires, spills and first aid. Some have been translated into Spanish.

Drugs

Databases and other resources on drugs are widespread on the Web. In addition to resources already covered, particularly the FDA, summary information on drugs, including extensive data on adverse effects, is offered by RxList (http://www.rxlist.com). The U.S. Pharmacopoeia’s advice for the patient is made available through NLM’s MEDLINEplus (http://www.nlm.nih.gov/medlineplus/druginformation.htm) and information related to drugs used in clinical trials is searchable at ClinicalTrials.gov (http://clinicaltrials.gov). WebMD’s Health also has good drug information (http://my.webmd.com/drugs) geared to the patient.
Pesticides

In addition to extensive information on pesticides provided by the U.S. EPA through the Office of Pesticide Programs (http://www.epa.gov/pesticides/), several other resources are listed below.

The National Pesticide Information Center (http://npic.orst.edu/) is a cooperative effort of Oregon State University and the U.S. EPA and sponsors a toll-free phone number (1-800-858-7378) for pesticide information as well as fact sheets, links, and other information such as a list of pesticide manufacturers from its Web site.

EXTOXNET (http://ace.orst.edu/info/extoxnet/), a cooperative project of several universities, with primary files maintained by Oregon State University, this site provides science-based information on pesticides for the nonexpert.

A recent review has detailed many Web resources devoted to pesticides.[10]

Food Borne and Plant and Animal Toxins

The “Bad Bug Book” (aka Food Borne Pathogenic Microorganisms and Natural Toxins Handbook) (http://www.cfsan.fda.gov/~mow/intro.html) is a useful resource from the FDA’s Center for Food Safety and Applied Nutrition.

Guide to Snakes from Duke University’s Biological and Environmental Sciences Library http://www.lib.duke.edu/bes/reptiles/snakes.htm provides links to a great many venomous snake resources, including Terence Davidson’s Snake Bite Protocols.

A large number of food and nutrition sites are listed on a site sponsored by the U.C. Davis FoodSafe program (http://foodsafe.ucdavis.edu/fslinksframe.html).

Cornell University’s Poisonous Plants Informational Database (http://www.anisci.cornell.edu/plants/index.html) offers plant images, pictures of affected animals, and presentations concerning the botany, chemistry, toxicology, diagnosis, and prevention of poisoning of animals by plants and other natural flora.

Another good source for data on plants that cause poisoning in livestock, pets, and humans, is the Canadian Poisonous Plants Information System (http://sis.agr.gc.ca/poison).

A CD-ROM database called Venoms offering information in the field of venomous animals, their venoms and envenomations is available from Atheris Laboratories in Switzerland (http://www.atheris.ch/venoms.html).

The Serpentarium Database (http://ntri.tamu.edu/serp/), maintained by the National Toxins Research Center at Texas A&M University, offers data on species of snakes of interest to venom researchers.

Oklahoma State University has compiled an Online Safety Library of Internet Links on poisonous plants, animals, and arthropods (http://www.pp.okstate.edu/ehs/links/poison.htm).

Chemical Accidents and Poisoning Incidence

The Chemical Incidents Report Center (United States Chemical Safety and Hazard Investigation Board) (http://www.chemsafety.gov/circ/) gathers information and builds databases on chemical incidents—fires, explosions, spills, leaks, etc.—from around the world.

The Chemical Transportation Emergency Center (CHEMTREC) (http://www.chemtrec.org) was established by the chemical industry as a public service hotline for emergency responders to obtain information and assistance for emergency incidents involving chemicals and hazardous materials. Among other information, CHEMTREC can provide physicians and other medical specialists with treatment information for acute exposures.

CAMEO (http://www.epa.gov/ceppo/cameo/), developed by the EPA and NOAA, is a system of software applications, downloadable from the Web and used to plan for and respond to chemical emergencies.

The Toxic Effects Surveillance System (TESS) (AAPCC) (http://www.aapcc.org/poison1.htm) contains detailed toxicological information on some 30 million poison exposures reported to U.S. poison centers. Summaries of the data from 1983 to present are available at http://www.aapcc.org/annual.htm. Full data sets are available for sale from the AAPCC.

Chemical and Biological Warfare

The terrorist attacks on the United States on September 11, 2001, have sparked an increased interest in chemical and biological warfare agents—what they are, their effects, and how to medically manage exposure. Increased attention is now being paid to coordinating information to help respond to possible future attacks.[11]
The following two compendia from the NLM offer links to many other Web resources on these topics:


Biological Warfare (http://sis.nlm.nih.gov/Tox/biologicalwarfare.htm)

Journals, Newsletters, and Current Awareness

Many traditional paper journals are now also available online by subscription. Some journals are available only online and some are available for free. The list below is only a sampling. Many journals, whose emphases lay elsewhere, also publish papers highly relevant to clinical toxicology. The world of publishing is in as great a flux as the world of the Internet so that you may expect not only that some of these journal site URLs will change over time, but that their publishers will as well.

Current Awareness in Clinical Toxicology (Birmingham Centre of the U.K.’s National Poisons Information Service) (http://www.npis.org/cact/cact.htm) offers a select list of references relevant to clinical toxicology.


Internet Journal of Medical Toxicology (http://www.ijmt.net/) is a free exclusively online journal and is published by the American College of Toxicology.

Journal of Toxicology: Clinical Toxicology (Marcel Dekker) (http://www.dekker.com/servlet/product/productid/CLT) is the official journal of the AACT and European Association of Poisons Centres and Clinical Toxicologists. This journal periodically highlights Web sites relevant to clinical toxicology.


Toxicon (Elsevier Science), an official journal of the International Society on Toxinology, published articles on toxins derived from animals, plants, and microorganisms (http://www.elsevier.nl/locate/toxicon).

Veterinary and Human Toxicology (http://www.napcc.aspca.org/vhtox/edition.html), a cross between a standard scientific journal and a newsletter, offers informative and entertaining reading. Selected abstracts and occasional full-text articles are offered online, but to see it all, including the great cartoons, still requires a paid subscription for the paper copy.

Several prominent scientific and medical journals also periodically publish articles in clinical toxicology. Nature (http://www.nature.com), the Lancet (http://www.thelancet.com), the British Medical Journal (http://bmj.com), the New England Journal of Medicine (http://content.nejm.org) and JAMA (http://jama.ama-assn.org) are among them.

Handheld Devices

Applications for personal digital assistants (PDAs) are still in their infancy. There is great potential for toxicologists to carry in their pockets a portable encyclopedia and diagnostic/therapeutic information tool.[12] PDAs continue to evolve and their increasing efficiency at connecting to the Web to download and update information will enhance their value in the field. Among the recent ventures worth exploring are:

Palm Tox (http://www.hypertox.com)

MobileMICROMEDEX (http://www.micromedex.com/products/pd-mobile.htm)—includes drug information, alternative medicine, acute care, and toxicology data

Pepid (http://pepid.com/main.asp)

e-medicine toxicology (http://www.emedicine.com/emerg/TOXICOLOGY.htm)

ToxWizard (http://www.collectivemed.com/p_toxwi.html)

5-Minute Consult in Toxicology (http://www.lww.com/productdetailresults/1,2265,509513716,00.html)

Scenario

Web and other electronic resources, such as the ones discussed above, are useful during the evaluation and management of poisoned patients. Most hospital critical
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care units and emergency departments now have online access. This allows health-care providers to directly access literature, electronic texts, databases, and other useful Web sites. The following scenario describes how these resources may be used in a toxicologist’s evaluation and management of a poisoned patient.

For example, an emergency physician receives a pre-hospital provider about a train derailment involving a chemical spill. He is informed that a number of people were exposed and one is in critical condition. After everyone was moved to safety, a tank car apparently caught fire.

The physician is informed by emergency medical technicians over radio communications that there is a numbered placard on the rail car with the number “2783” clearly visible. The physician retrieves the Department of Transportation’s Emergency Response Guidebook (ERG) (http://hazmat.dot.gov/gydebook.htm) on the ED computer and identifies the number as representing any of a number of organophosphorus pesticides. These include azinphos methyl, chlorpyrifos, cumaphos, diazinon, dichlorvos, disulfoton, ethion, guthion, hexaethyl tetraphosphate mixture, malathion, methyl parathion, mevinphos, parathion, tetraethyl pyrophosphate mixture, and trichlorfon.

The field emergency response team has summoned a rescue helicopter to transport the critical patient to the Regional Poison Treatment Center.

The medical flight crew has taken over the care of the patient and radios the ED advising that they have a 32-year-old male patient. The patient was the train’s conductor and had gone to inspect the derailed car to determine the extent of the accident when he was overcome. He was discovered unresponsive, and his clothing smelled of hydrocarbons. There were no obvious signs of trauma. No additional history was available. The flight crew arrives and gives the physician the following description: pulse 146 and regular; blood pressure 138/88; respiratory rate 42, shallow and labored. The patient is described as sweating, though the ambient temperature is 60°F with copious amounts of frothy secretions emanating from his mouth and nose. His pupils are small and there is evidence of urinary and fecal incontinence. The medics have orally intubated the patient and have good intravenous access. They are requesting further care orders.

The physician’s preliminary diagnosis, based on the placarding and the presenting physical signs of the patient, is organophosphate poisoning. The emergency physician recalls that the two main antidotes are atropine and an oxime. Atropine 1 milligram IV and decontamination of the patient are ordered. He consults the MICROMEDEX ChemKnowledge® system (http://www.micromedex.com/products/ChemKnowledge) for specific information on organophosphates and antidote dosing. He confirms that his initial clinical impressions are reasonable. He also notes that he may need large amounts of both atropine and pralidoxime (an oxime), and requests that these brought to the ED from the hospital pharmacy. He consults the NLM’s HSDB on the TOXNET system (http://toxnet.nlm.nih.gov) for physical properties of the insecticide and determines that it is of very low volatility and is heavier than air indicating that the field rescuers are possibly still at risk, since the leak may result in a cloud that may remain close to the ground. He also learns a likely diluent is xylene.

The physician is informed that the patient has been washed with soap and water by the Hazmat team and there appears to be a partial response from the atropine. He orders another milligram of the antidote and conveys to the critical care unit under the care of a medical toxicologist. He orders another milligram of the antidote and conveys that the patient may require still more during the transport in order to minimize secretions.

The shipping papers are located and reveal that the specific organophosphate in the rail car was malathion. The physician consults an online laboratory index (http://www.pactox.com/) for details on testing the patient for malathion poisoning. The laboratory recommends that RBC and plasma cholinesterase tests be conducted, and that the urine be measured for maloxon, a malathion metabolite. The lab site provides specific information on the types of blood and urine collection containers for the tests.

The patient arrives at the ED and is placed in a resuscitation room. The physician’s initial impressions are confirmed by a careful evaluation of the history and physical findings of the patient. At this point the toxicologist may consult a handheld computer drug database (e.g., LexiDrugs—http://www.medicalpocketpc.com/articles/lexidrugs.shtml, or mobile Micromedex—http://www.micromedex.com) for drug dosing information on atropine and pralidoxime. The recommended dose is 1–2 g of pralidoxime given IV over 5–10 minutes every 6 hours. Atropine is titrated to keep the airway clear of secretions. The patient’s clothing is disposed of as a hazardous material. He is further decontaminated with soap and water, and stabilized. He is transferred to the critical care unit under the care of a medical toxicologist. The patient requires continued dosing with atropine and pralidoxime, and is extubated in 2 days.

The nursing staff tells the toxicologist that the family of the patient has read on the Web that malathion may
cause cancer and they would like to discuss the relevance of this finding to his recovery. The toxicologist’s next step is to search various online databases that may have information on the carcinogenicity of malathion. Some relevant databases are available on the Web through the IARC (http://www.iarc.fr), the IRIS, (http://www.epa.gov/iris) and the NTP (http://ntp-server.nih.gov). Although there appears to be some evidence of carcinogenicity in animals, it is not sufficient to assess human carcinogenic potential. He proceeds to search the NLM’s TOXLINE databases (http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?TOXLINE) for recent articles reporting on exposure to malathion and potential cancer development.

The above scenario is but one of a myriad of cases that the emergency physician and medical toxicologist may encounter in his daily work. Occupational exposures, childhood poisoning, and accidents at industrial sites, drug abuse cases, and insect bites and stings and among the other classes of cases he regularly contends with. Regardless of the type, though, he has increasingly come to rely on the Web and other digital tools for his information needs.

REFERENCES