Abstract

We have developed a drug poisoning subsystem based on the Consult-I language. The system is trained from estimation of the frequency of occurrence of various signs and symptoms based on review of the literature. In preliminary testing with single drug cases the system achieved an accuracy of 70%.

Introduction

Acute drug poisoning is a common problem presenting to Emergency Departments. Frequently the history of the causative agent is unknown or unreliable. Identification of the unknown poison is important because of specific therapeutic modalities and precautions that should be taken for certain drugs. Laboratory identification of drugs is time consuming and not universally available. However, certain classes of drugs are suggested by a specific constellation of signs and symptoms. We have designed a drug poisoning identification subsystem utilizing the Consult-I language of artificial intelligence and statistical pattern recognition.

The Consult-I language is a high level language which can be used without a knowledge of computer programming. The developer uses the rules of the language to develop the classes (type of disease, i.e. methanol poisoning), features (signs, symptoms and laboratory data, i.e. reflexes) and feature values (i.e. for reflexes: hyporeflexia, normo-reflexic, and hyperreflexia).

The Consult-I model developed by Patrick et al. (1-10) provides that there are M categories \( y_1, y_2, \ldots, y_M \) which are defined in terms of classes \( w_1, w_2, \ldots, w_M \). A class \( w_i \) such as methanol poisoning may occur alone as an only class \( w_i^* \) or may occur as a complex class \( C_i^* \) containing methanol and some combination of other drugs.

The classes and feature vectors have probabilities:

\[
\begin{align*}
    p(w_i^*) & : \text{apriori probability of the class containing only drug } i^* \quad (1) \\
    p(C_i^*) & : \text{apriori probability of the class containing a combination of drugs \( i \) included.} \quad (2)
\end{align*}
\]

The a posteriori probability of a class is given by Patrick's theorem (1):

\[
p(w_i | x) = p(x | w_i^*) p(w_i^*) + \sum p(x | C_i^*) p(C_i^*)
\]

which reduces to Bayes theorem when there are no complex classes.

Diagnosis of specific classes of drug poisoning revolves around a constellation of signs, symptoms, and laboratory values (11,12). These include such features as CNS and GI toxicity, cardiovascular effect, acid/base and electrolyte balance, and autonomic signs. Consideration of these features provides the physician usually not with a specific diagnosis, but rather with a differential diagnosis that includes the causative agent. Identification of a specific agent requires a toxicologic laboratory that may or may not be available at a needed time or place.

We have trained our system to recognize 23 classes of drug poisoning (Figure 1). This list includes the agents most commonly seen in Emergency Departments as well as some less common ones (13). The features which the computer uses to recognize these classes are listed in Figure 2. Note that the features may have mutually exclusive values (i.e. reflexes: hypo, normo, and hyperreflexic) or may take on more than one value (i.e. GI effect: diarrhea, vomiting, abdominal pain, ileus, GI bleeding). The probability of each feature value given a certain drug class is estimated from a review of the medical literature. For some of the drug classes such as methanol, tricyclics, or PCP, there have been studies of sign/symptom complexes over a large group of patients. For other drug classes the literature gives only generalizations such as "rarely occurs" or "usually occurs." This lack of precision introduces some lack of precision into our system. Certain signs or symptoms such as reflexes or blurred vision are subjective. For these features we have programmed smaller differences in probability value than for more objective data such as acid/base balance. However, for a system such as drug poisoning much of the data is observation oriented. We would expect our system to be less precise than one based more on laboratory data.
Method

As a preliminary test of the system, we conducted a retrospective review of 20 cases from the Emergency Department at Cleveland Metropolitan General Hospital. The cases were of patients of varying age who had taken deliberate overdose of a single drug. Complex cases of multiple drug overdose were not tested at this time. Diagnosis was confirmed by toxicologic analysis at a commercial laboratory. The computer program is such that one can input data for all the features listed in Figure 2, or can indicate that certain features are missing. Data used for testing the system was not used to train the system. We chose to test the system as a differential diagnosis containing the drug in the top three rate classes as this would seem to be the process most like that a physician would undertake.

Results

In preliminary testing, the system chose the correct drug in the top three choices of the differential diagnosis in 14 of 20 cases (70%). Most of our cases involved sedatives and psychoactive drugs. Many of these drugs may have a similar clinical picture during overdose. We did not have the presentations to test the system for classes with a more distinctive presentation such as ethylene glycol or methanol.

Summary

We have developed a drug poisoning system based on the Consult-I language. This system utilizes a Bayes framework to estimate a class conditional probability density function. This system tests 23 classes of drugs over 21 features. In preliminary testing this system achieved a correct choice in the top three of the differential in 70% of cases. More extensive testing and testing for multiple drug overdose is planned.

![Figure 1](drug_classes.png)

**Drug Classes**

- Barbiturates
- Ethanol
- Ethchlorvynil
- Chloral Hydrate
- Isopropyl Alcohol
- Benzodiazepines
- Lithium
- Glutethimide
- Dilantin
- Phenoxybenzamine
- Organophosphates
- Ethylene Glycol
- Antihistamines
- Tricyclics
- Digitalis
- Propranolol
- Methanol
- PCE
- Salicylate
- Iron
- Narcotics
- Cocaine

![Figure 2](features.png)

**Features**

1. **AGE**
   - 1. Pediatric
   - 2. Adult
   - 3. Elderly

2. **MECHANISM OF POISONING**
   - 1. Inhalation
   - 2. Ingestion
   - 3. Injection
   - 4. Skin contact

3. **HEART RATE**
   - 1. Decreased
   - 2. Normal
   - 3. Increased

4. **RESPIRATORY RATE**
   - 1. Decreased
   - 2. Normal
   - 3. Increased

5. **BLOOD PRESSURE**
   - 1. Hypotensive
   - 2. Normal
   - 3. Hypertensive

6. **TEMPERATURE**
   - 1. Decreased
   - 2. Normal
   - 3. Increased

7. **STATE OF CONSCIOUSNESS**
   - 1. Alternating
   - 2. Depressed
   - 3. Alert

8. **MENTAL STATUS**
   - 1. Anxiety
   - 2. Agitation
   - 3. Confused
   - 4. Hallucinations
   - 5. Paranoid
   - 6. Psychotic

9. **PUPILS**
   - 1. Pinpoint
   - 2. Constricted but not pinpoint
   - 3. Normal
   - 4. Dilated

10. **PUPIL REACTIVITY**
    - 1. Nonreactive
    - 2. Poorly reactive
    - 3. Reactive

11. **EYE SIGNS**
    - 1. Blurred vision
    - 2. Scotomas
    - 3. Nystagmus
    - 4. Photophobia
    - 5. Loss of corneal reflex
    - 6. Papilledema
    - 7. Blindness

12. **NEUROLOGICAL**
    - 1. Slurred speech
    - 2. Ataxia
    - 3. Headache
    - 4. Dystonia
    - 5. Tenor
    - 6. Muscle weakness
7. Myoclonus
8. Paralysis
9. Seizures

13. REFLEXES
1. Hyporeflexic
2. Normal
3. Hypereflexic

14. AUTONOMIC SIGNS
1. Dry skin
2. Diaphoresis
3. Salivation
4. Dry mouth
5. Sneezing
6. Flush skin color
7. Cheyne-Stokes respiration
8. Urinary retention
9. Urinary incontinence

15. GI EFFECT
1. Diarrhea
2. Nausea or vomiting
3. Abdominal pain
4. Illness
5. GI bleeding

16. EKG
1. Increased PR interval
2. Increased QRS
3. Increased QT interval
4. Conduction defect
5. ST or T wave abnormalities

17. ARRHYTHMIAS
1. Atrial fibrillation or flutter
2. Supraventricular tachycardia
3. AV block
4. Premature ventricular contractions
5. Ventricular tachycardia

18. GLUCOSE
1. Decreased
2. Normal
3. Eased

19. BLOOD GASES
1. Metabolic acidosis
2. Metabolic alkalosis
3. Respiratory acidosis
4. Respiratory alkalosis

20. ANION GAP
1. Normal
2. Increased

21. OSMOLAR GAP
1. Normal
2. Increased

References