Drugs and Toxicology

Come in and get your notebooks out. We have notes today!
The Role Of Forensic Toxicology

• Toxicologists detect and identify drugs and poisons in body fluids, tissues, & organs to determine their influence on human behavior

• They can work in legal institutions such as crime labs and medical examiners’ offices

• In hospital labs- where identifying a drug overdose may represent the difference between life and death

• In other facilities that monitor the intake of drugs and other toxic substances (blood tests on children exposed to lead paints, analyzing urine for drugs for employers)
What is a Toxicology?

• The study of poisons and the identification of drugs and other substances a person may have used for medicinal, recreational, or criminal purposes
• Also examines the harmful effects of poisons and drugs on the body
Methods of Exposure

• **Gastrointestinal**: the substance is ingested
• **Respiratory**: the substance is inhaled into the lungs
• **Cardiovascular**: the substance is injected into the bloodstream
• **Cutaneous**: the substance is absorbed through the skin
Toxicity

• The degree to which a substance is poisonous or can cause injury

• Dependent on:
  • **Dose:** how much was taken
  • **Duration:** frequency or length of exposure
  • **Nature of exposure:** was it ingested, inhaled, etc.
Forensic Toxicology

• Determines the cause and effect relationship between exposure to a substance and the toxic or lethal effects from that exposure

• Exposure is determined by testing:
  • **Body fluids:** urine or blood
  • **Stomach contents**
  • **Skin**
  • **Hair**
  • **Liver**: tested only if the exposure was lethal
  • **Eye**: vitreous humor

**These organs are tested only if the exposure was lethal**
Acute vs. Chronic Poisoning

- **Acute poisoning**: caused by high dose over a short period of time; ex: cyanide
- **Chronic poisoning**: caused by lower doses over long periods of time; ex: lead
Controlled Substances

• Drugs whose sale, possession, and use are restricted because of the effect of the drugs and the potential for abuse

• There are 5 classes of controlled substances:
  • *Hallucinogens*
  • *Narcotics*
  • *Stimulants*
  • *Anabolic steroids*
  • *Depressants*
Drugs and Toxicology

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Did you know?

• 23 Million Americans use illicit drugs.
• Marijuana is the mostly widely used illicit drug in the US.
• All social/ethnic class abuse drugs.

• 75% of all evidence evaluated in crime labs is drug-related
Depends on:
* nature of drug and the dose
* how administrated
* frequency of use
* behavioral patterns
* society’s attitudes

2 types of Dependence:
* Psychological: emotional need
* Physiological: physical need
Physical Drug Evidence
--possibly found at crime scene
--active drug and may have additives

• Powder
• Tablets
• Capsules
• Liquids
• Vegetable or Plant Matter
Possible Drug Paraphernalia
--possibly found at crime scene
--may contain drug residues to test

• Pipes
• Cigarettes
• Cookers
• Syringes
• Other inhalational

Or usage devices
Collecting Evidence:

When a warrant is issued, locations are searched for the drug or any paraphernalia.

There are times where, if probable cause is met, officers will search cars or persons and possibly discover drugs.

Drug dogs could also be utilized to find drugs.
Drug Dogs

• Humans do not have a good sense of smell because as air enters the nose it must make a hairpin to reach the olfactory cells (nerve cells responsible for the sense of smell)

• In dogs, air enters the nose and reaches the olfactory cells directly so that dogs have a sense of smell that is 200 times better than humans
Drug Dogs

• Usually Labradors and German shepherds are chosen to be drug dogs, but the temperament of the dog is more important than the breed of the dog.

• The dog can be trained as either a **passive response** or **aggressive response** dog.

• A passive response dog will point to the odor.

• An aggressive response dog will scratch and bark when it discovers the odor.
Types of Searches

• **Fire scene searches:** dogs are trained to detect fire accelerants
• **Vehicle searches:** these dogs search vehicles for drugs or explosives
• **Crowd searches:** dogs on leashes will search a crowd of people
• **Area searches:** dogs will search an area such as a field or forest
• When possible, blood and urine are taken
• The entire urine sample is collected for analysis
• Preferably, two consecutive voids should be collected in separate containers
• For drug and poison exams, about 10 mL of blood needs to be collected
• For the presence of alcohol, only 5 mL of blood is needed
Collection & Preservation of Blood

- Apply nonalcoholic disinfectant before drawing blood with a needle (Zepiran, mercuric chloride, Betadine)
- Once removed from person, it is preserved in a vacutainer containing anticoagulant (prevents clotting) and a preservative (inhibits growth of bacteria that can destroy alcohol)
- This must then be refrigerated
- In postmortem: added precaution because alcohol may be generated as a result of bacterial action
- Blood may be removed from heart, femoral (leg) and cubital (arm) veins
- Collection of vitreous humor & urine must be collected in these individuals (no bacterial production from bacteria)
Techniques Used

- **pH**: acids are less than 7, bases are greater than 7
- Acid drugs: barbiturates, aspirin
- Basic drugs: phencyclidine, methadone, amphetamines, cocaine
- Once a specimen has been classified as acid or base, drugs present may be identified
- **A screening test** is performed to give the likelihood that a specimen contains a drug substance
- This allows a toxicologist to examine a large number of specimens in a short amount of time for a wide range of drugs
- Any positive results must be verified with an extremely specific test called a **confirmatory test**
Drugs in Hair

- Most drugs remain in blood for 24 hrs
- In urine, up to 72 hrs
- May be necessary to go further back to determine if a drug has been abused
- Hair is nourished by blood flowing thru capillaries located close to hair root
- Drugs in blood diffuse into the base of the hair and become permanently trapped in the protein within the hair
- As the hair grows, the drug’s location becomes a marker for drug intake and amount of time abused
- Head hair grows 1 cm per month
- Analyzing hair for drugs can date drug use back over a period of weeks, months, and even a yr depending on the length of hair.
There are 5 classes of controlled substances

• Hallucinogens
  • Narcotics
  • Stimulants
• Anabolic steroids
• Depressants
Hallucinogens

- Often derived from plants
- Affect the user’s perceptions, thinking, self-awareness, and emotions

<table>
<thead>
<tr>
<th>DRUG</th>
<th>EXPOSURE</th>
<th>OVERDOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDMA</td>
<td>Pills</td>
<td>Increased heart rate and blood pressure, muscle cramps, panic attacks,</td>
</tr>
<tr>
<td>3,4-Methylene Dioxyamphetamine (Ecstasy)</td>
<td></td>
<td>seizures, stroke, loss of consciousness, death</td>
</tr>
<tr>
<td>DRUG</td>
<td>EXPOSURE</td>
<td>OVERDOSE</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Mescaline</td>
<td>Smoked or swallowed</td>
<td>Hallucinations, euphoria, dizziness, vomiting, increased heart rate, dilated pupils, headache, anxiety</td>
</tr>
<tr>
<td>LSD, Lysergic acid diethylamide</td>
<td>Swallowed or absorbed</td>
<td>Dilated pupils, loss of appetite, sleeplessness, increased body temperature, increased heart rate and blood pressure</td>
</tr>
<tr>
<td>PCP, Phencyclidine (angel dust)</td>
<td>Sniffed, swallowed, smoked, injected</td>
<td>Increased heart rate and blood pressure, sweating, dizziness, convulsions</td>
</tr>
</tbody>
</table>
Narcotics

• Act to reduce pain by suppressing the central nervous system’s ability to relay pain messages to the brain
• Include opium and its derivatives, heroin and codeine
• Very habit forming
<table>
<thead>
<tr>
<th>DRUG</th>
<th>EXPOSURE</th>
<th>OVERDOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opium</td>
<td>Smoked or swallowed</td>
<td>Low blood pressure, weakness, labored breathing, dizziness, confusion, small pupils, coma</td>
</tr>
<tr>
<td>Heroin</td>
<td>Swallowed or injected</td>
<td>Low blood pressure, difficulty breathing, coma, stomach spasms, nausea, vomiting</td>
</tr>
<tr>
<td>Codeine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morphine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methadone</td>
<td>Swallowed</td>
<td>Difficulty breathing, drowsiness, coma, low blood pressure, muscle twitches</td>
</tr>
<tr>
<td>Oxycodone (ex: percocet)</td>
<td>Swallowed</td>
<td>Slow, difficult breathing, seizures, dizziness, weakness, confusion, coma</td>
</tr>
</tbody>
</table>
Stimulants

• Increase feelings of energy and alertness while suppressing appetite
• Depression is a common result as the effect of the drug wear off
• Highly addictive
<table>
<thead>
<tr>
<th>DRUG</th>
<th>EXPOSURE</th>
<th>OVERDOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphetamines</td>
<td>Swallowed, sniffed,</td>
<td>High blood pressure, rapid heart rate, agitation, irregular heartbeat, stroke, seizures, coma, death</td>
</tr>
<tr>
<td>(speed)</td>
<td>injected, smoked</td>
<td></td>
</tr>
<tr>
<td>Cocaine/crack</td>
<td>Sniffed, injected,</td>
<td>Dangerous rise in body temperature, sweating, tremors, seizures, irregular heartbeat, stroke, heart attack</td>
</tr>
<tr>
<td>Methamphetamines</td>
<td>Sniffed, injected,</td>
<td>Dangerous rise in body temperature, profuse sweating, rapid breathing, dilated pupils, brain bleeding, death</td>
</tr>
<tr>
<td></td>
<td>swallowed, smoked</td>
<td></td>
</tr>
</tbody>
</table>
Anabolic Steroids

• Promote cell and tissue growth and cell division
• Have a structure similar to testosterone

• Side effects of steroid use include acne, high blood pressure, male infertility, kidney and liver cancers
Depressants

• Relieve anxiety and produce sleep
• Reduce body functions such as heart rate, by acting on the central nervous system

<table>
<thead>
<tr>
<th>DRUG</th>
<th>EXPOSURE</th>
<th>OVERDOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barbiturates and Benzodiazepines</td>
<td>Swallowed</td>
<td>Slurred speech, slowed breathing, drowsiness, difficulty thinking,</td>
</tr>
<tr>
<td>Alcohol</td>
<td>Swallowed</td>
<td>Slurred speech, slowed breathing, impaired thinking</td>
</tr>
</tbody>
</table>
Organic Toxins

- Poisonous substances produced by living organisms
- **Venom**: toxin secreted by an animal that can be transferred to a human
Organic Toxins (cont.)

- **Bacterial toxin:** secreted by bacterial cells

- *Clostridium botulinum* produces the **botulism** toxin which paralyzes muscles by blocking acetylcholine

- *Clostridium tetani* produces the toxin that causes **tetanus**, a condition in which nerve signals from the spinal cord to the muscles are blocked
Heavy Metals

• Enter the body through ingestion, inhalation, or absorption
• Stored in the soft tissues and can damage many organs
<table>
<thead>
<tr>
<th>METAL</th>
<th>OVERDOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>Nausea, abdominal pain, insomnia, headache, weight loss, constipation,</td>
</tr>
<tr>
<td></td>
<td>anemia, kidney problem, vomiting, seizure, coma and death</td>
</tr>
<tr>
<td>Mercury</td>
<td>Muscle aches, upset stomach, irritability, personality changes, headache,</td>
</tr>
<tr>
<td></td>
<td>memory and balance problems, abdominal pain</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Abdominal pain, severe nausea, vomiting, diarrhea, muscle cramps,</td>
</tr>
<tr>
<td></td>
<td>convulsions, kidney failure, death</td>
</tr>
<tr>
<td>Cyanide</td>
<td>Fatal within 6-8 minutes, rapid weakness, confusion, coma</td>
</tr>
<tr>
<td>Strychnine</td>
<td>Body spasms, temperature rises, violent convulsions, rigor mortis</td>
</tr>
<tr>
<td></td>
<td>within minutes</td>
</tr>
</tbody>
</table>
Bioterrorism

• **Ricin**: lethal in small quantities (500 micrograms); can be inhaled as a mist or powder, or ingested in food or drink; interferes with protein production

• **Anthrax**: caused by *Bacillus anthracis* spores; produces flu-like symptoms that include breathing problems that eventually lead to death
<table>
<thead>
<tr>
<th>SCHEDULE</th>
<th>DESCRIPTION</th>
<th>EXAMPLES</th>
</tr>
</thead>
</table>
| Schedule 1| Drugs with no currently accepted medical use and a high potential for abuse. They are the most dangerous drugs of all the drug schedules with potentially severe psychological or physical dependence. | - Heroin  
- Lysergic acid diethylamide (LSD)  
- Marijuana (Cannabis)  
- Methylenedioxymethamphetamine (Ecstasy)  
- Methaqualone  
- Peyote |
| Schedule 2| Drugs with a high potential for abuse, with use potentially leading to severe psychological or physical dependence. These drugs are also considered dangerous. | - Combination products with less than 15mg of hydrocodone per dosage unit (Vicodin)  
- Cocaine  
- methamphetamine  
- Methadone  
- Hydromorphone (Dilaudid)  
- Meperidine (Demerol)  
- Oxycodone (OxyContin)  
- Fentanyl  
- Dexedrine  
- Adderall  
- Ritalin |
| Schedule 3 | Drugs with a moderate to low potential for physical and psychological dependence. Schedule 3 drugs abuse potential is less than Schedule 1 and Schedule 2 drugs but more than Schedule 4. | - Products containing less than 90mg of codeine per dosage unit (Tylenol and codeine)  
- Ketamine  
- Anabolic steroids  
- Testosterone |
| Schedule 4 | Drugs with a low potential for abuse and low risk of dependence. | - Xanax  
- Soma  
- Darvon  
- Darvocet  
- Valium  
- Ativan  
- Talwin  
- Ambien  
- Tramadol |
| Schedule 5 | Drugs with lower potential for abuse than Schedule 4 and consist of preparations containing limited quantities of certain narcotics. Schedule 5 drugs are generally used for antidiarrheal, antitussive, and analgesic purposes. | - Cough preparations with less than 200mg of codeine per 100ml (Robitussin AC)  
- Lomotil  
- Motofen  
- Lyrica  
- Parepectolin |
A Closer look into ALCOHOL

Come in and get your notebooks out. We have notes today!
Alcohol

- Ethanol or ethyl alcohol is contained in alcoholic beverages
- It is a depressant and works on the brain “from the top down” so that higher functions such as social behaviors, logic, memory are affected first
- It is an addictive drug

Did You Know...

- Ethyl alcohol is the most heavily abused drug
- 40% of all traffic deaths in the U.S., nearly 17,500 fatalities per year, are alcohol related, along with 2 million injuries each year requiring hospitalization
Units

• 1 unit of alcohol is equal to the amount of alcohol in a standard drink
• 1 unit is approximately equal to 10 g of pure alcohol
Alcohol Content

• Usually measured by the percent of alcohol by volume
• For example: 4% by volume means that there are 4 milliliters of alcohol per 100 ml of solution
Alcohol Absorption

- 20% of alcohol is absorbed by the stomach
- Gastric emptying is slowed by food in the stomach
- The other 80% is absorbed by the first part of the small intestine
- Alcohol is absorbed by passive diffusion and so will continue as long as the alcohol concentration in the stomach or small intestine is higher than the alcohol concentration in the blood
- Absorption is usually completed in 1-3 hours
Alcohol Absorption (cont.)

- The body absorbs alcohol in the blood and in the water within the body.
- Muscles, which have a higher water concentration than fat, will absorb more alcohol.
- The concentration of alcohol in the blood is equal to the amount of alcohol consumed divided by the volume of water in the body.
- A lean person with lots of muscle distributes alcohol better than an obese person of similar weight.
Rule of Thumb for Determining BAC

• In men, 1 unit of alcohol will increase the BAC by 15 mg/100 ml in one hour
• For women, 1 unit increases the BAC by 20 mg/100 ml
### BAC Determination

**Males**

<table>
<thead>
<tr>
<th>Drinks</th>
<th>Body Weight in Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00</td>
</tr>
<tr>
<td>1</td>
<td>0.04 0.03 0.03 0.02 0.02 0.02 0.02 0.02</td>
</tr>
<tr>
<td>2</td>
<td>0.08 0.06 0.05 0.05 0.04 0.04 0.03 0.03</td>
</tr>
<tr>
<td>3</td>
<td>0.11 0.09 0.08 0.07 0.06 0.06 0.06 0.05</td>
</tr>
<tr>
<td>4</td>
<td>0.15 0.12 0.11 0.09 0.08 0.08 0.07 0.06</td>
</tr>
<tr>
<td>5</td>
<td>0.19 0.16 0.13 0.12 0.11 0.09 0.09 0.08</td>
</tr>
<tr>
<td>6</td>
<td>0.23 0.19 0.16 0.14 0.13 0.11 0.10 0.09</td>
</tr>
<tr>
<td>7</td>
<td>0.26 0.22 0.19 0.16 0.15 0.13 0.12 0.11</td>
</tr>
<tr>
<td>8</td>
<td>0.30 0.25 0.21 0.19 0.17 0.15 0.14 0.13</td>
</tr>
<tr>
<td>9</td>
<td>0.34 0.28 0.24 0.21 0.19 0.17 0.15 0.14</td>
</tr>
<tr>
<td>10</td>
<td>0.38 0.31 0.27 0.23 0.21 0.19 0.17 0.16</td>
</tr>
</tbody>
</table>

**Females**

<table>
<thead>
<tr>
<th>Drinks</th>
<th>Body Weight in Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00</td>
</tr>
<tr>
<td>1</td>
<td>0.05 0.04 0.03 0.03 0.03 0.02 0.02 0.02</td>
</tr>
<tr>
<td>2</td>
<td>0.10 0.09 0.08 0.07 0.06 0.05 0.05 0.04</td>
</tr>
<tr>
<td>3</td>
<td>0.15 0.14 0.11 0.11 0.09 0.08 0.07 0.06</td>
</tr>
<tr>
<td>4</td>
<td>0.20 0.18 0.15 0.13 0.11 0.10 0.09 0.08</td>
</tr>
<tr>
<td>5</td>
<td>0.25 0.23 0.19 0.16 0.14 0.13 0.11 0.10</td>
</tr>
<tr>
<td>6</td>
<td>0.30 0.27 0.23 0.19 0.17 0.15 0.14 0.13</td>
</tr>
<tr>
<td>7</td>
<td>0.35 0.32 0.27 0.23 0.20 0.18 0.16 0.14</td>
</tr>
<tr>
<td>8</td>
<td>0.40 0.36 0.30 0.26 0.23 0.20 0.18 0.17</td>
</tr>
<tr>
<td>9</td>
<td>0.45 0.41 0.34 0.29 0.26 0.23 0.20 0.19</td>
</tr>
<tr>
<td>10</td>
<td>0.50 0.45 0.38 0.32 0.28 0.25 0.23 0.21</td>
</tr>
</tbody>
</table>
Elimination of Alcohol

• 5% of alcohol is eliminated in the breath
• 5% is eliminated in the urine
• 90% is eliminated in the liver
• The average rate of elimination of alcohol is 15 mg of alcohol/100 ml of blood per hour or 1 unit/hour
• The range of elimination is 10-40 mg/100 ml/hour
Widmark Equation

• This equation is used as a rough estimate of peak BAC

\[
\text{BAC} = \frac{A \times 5.14}{\text{body weight(lbs.)} \times \text{Widmark factor}} - 0.015 \times H
\]

Where \( A = \# \text{ of liquid oz. of alcohol} \)

\( = \# \text{ of oz. consumed} \times \% \text{ alcohol} \)

\( H = \text{hours} \)

• Widmark factor is .68 for men and .55 for women

• EX: A 154-lb man consumes 3 beers within 1 hour. Estimate his blood alcohol level

\[
\text{BAC} = \frac{[(12 \text{ oz.})(3)(0.05)] \times 5.14}{154} \times 0.68 = 0.088
\]

\[
= 0.088 - (0.015)(1) = 0.073
\]
Because the alveoli (air sacs) in the lungs are in contact with the blood, there exists a ratio of the alcohol concentration in the breath to the alcohol concentration in the blood.

- This ratio is 1:2,300
- The breath alcohol content (BrAC) increases and decreases faster than blood levels.
State of Texas

• Drivers 21 and Over
  • First offense:
    • Up to a $2,000 fine
    • Possibly 72 hours to 180 days in jail
    • Driver license suspension: 90 days to one year
  • Second offense:
    • Up to a $4,000 fine
    • Thirty days to one year in jail
    • Driver license suspension: 180 days to two years
  • Third offense:
    • Up to a $10,000 fine
    • Two to 10 years behind bars
    • Driver's license suspension: 180 days to two years
State of Texas (cont.)

- Zero tolerance state for minors
- Any measurable amount of alcohol:
  - Sixty-day driver's license suspension
  - Up to a $500 fine
  - Twenty to 40 hours of community service
  - Mandatory attendance in alcohol-awareness classes
Drugs and Toxicology

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Forensic Drug Identification Methods:

- **Presumptive Test**: screening for active drug, narrows the possibilities.

- **Confirmatory Test**: more sophisticated test to pinpoint actual drug identity.
Forensic Drug ID:

Presumptive Test:

• *Field Test*: police officers normally do this test in the field before arrest

• *Also called Color Tests*
Presumptive Tests:

- **Marquis Test**: turns purple to detect heroin/morphine, turns orange-brown to detect amphetamines.
- **Vann Urk**: in the presence enough LSD will turn blue-purple.
Presumptive Tests:

- **Dillie-Koppanyi Test**: turns violet-blue to detect barbiturates.
- **Duquenois-Levine**: one layer turns purple to detect marijuana.
Presumptive Tests:

- **Scott Test:** 3 types of solutions that detect cocaine with these colors:
  1. 1\textsuperscript{st} turns blue
  2. 2\textsuperscript{nd} turn from blue to clear pink
  3. 3\textsuperscript{rd} turns pink to blue again
Confirmatory Tests:

• Presumptive samples are brought from field into the laboratory for further testing to identify actual drug.

• Microcrystalline test: chemical reagent added to drug sample on a microscope slide—crystal precipitate forms specifically according to drug type.
Confirmatory Tests:

Chromatography:

thin-layer chromatography (TLC) and gas chromatography separate drugs from their diluents into patterns individual for that drug.
Spectrophotometer:

Spectrophotometer measures the absorption of light in all regions of the spectrum (UV and IR used also) — IR is more specific to identify drugs.
Confirmatory Test:

Mass Spectrometry: drug sample is exposed to high energy electrons to break apart into ions---every type of drug molecule breaks apart differently.
Morphological Features

Microscope: make qualitative observations (look at drug samples)

Example: Marijuana has cystolithic hairs on both sides of it.