Key Disaster Types and Related Injury Conditions

Disaster Types and Pediatric Considerations
The table below highlights the types, symptoms, and treatment of common injuries resulting from the following disasters:

Natural Disasters

- Fire
- Flood
- Hurricane/Tornadoes
- Earthquake
- Infectious Epidemic

Manmade Disasters (SEE Terrorism Tools Section)
Chemical, Biological, Radiological, Nuclear, high-yield explosives (CBRNE) + F

Chemical
- Nerve Agents
- Toxic Industrial Chemicals
- Choking Agents
- Vesicants
- Irritants
- Cyanides

Biological
- Class A Biological Agents
- Class B Biological Agents

Radiological and Nuclear
- Ionizing
- Alpha
- Beta
- Gamma/x-rays
- Neutrons

Explosive
- High Order
- Low Order

Firearms
<table>
<thead>
<tr>
<th>Disasters Type</th>
<th>Specific Type</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Disasters</td>
<td>Fire</td>
<td>Burn management</td>
</tr>
</tbody>
</table>

- See wildfire acute pediatric care support from UCSF PEHSU: [http://www.ucsf.edu/ucpehsu/Wildfires_Acute_Phase.pdf](http://www.ucsf.edu/ucpehsu/Wildfires_Acute_Phase.pdf)
- See Environmental Health Hazards for Children in the Aftermath of Wildfires: [http://www.ucsf.edu/ucpehsu/Wildfires_Recovery_Phase.pdf](http://www.ucsf.edu/ucpehsu/Wildfires_Recovery_Phase.pdf)
- Larger skin to body surface area ratio
- Smaller airways increase risk of airway compromise with smoke inhalation
- Different body proportions than adult result in alterations of “rule of 9’s” for fluid resuscitation
- Post-Traumatic Stress Disorder (PTSD) increased risk in children

**Body Surface Percentages**

[Image of body surface percentages diagram]
<table>
<thead>
<tr>
<th>Disasters</th>
<th>Specific Type</th>
<th>Explanation</th>
</tr>
</thead>
</table>
| **Natural Disasters** | Flood | ▪ Drowning risk increased in non-swimmers  
▪ Increase in respiratory infections from exposure to elements  
▪ Communicable disease  
  ▪ GI Infections from waterborne and food-borne illness  
  ▪ Vector borne illness from stagnant water (Mosquitoes)  
  ▪ Wound infections from dirty water  
▪ Hypothermia: Children especially at risk  
▪ Loss of shelter  
▪ Separation from family  
▪ Psychological damage: Children at increased risk for PTSD |
| **Hurricane/Tornadoes** |  | ▪ Risks similar to flood  
▪ Additional risks  
  ▪ Damage from blunt trauma due to flying debris  
  ▪ Avoid windows during event |
| **Earthquake** |  | ▪ Vulnerable to trauma: Larger head, less circulatory volume reserves  
▪ Psychologically more prone to PTSD |
| **Infectious Epidemic** |  | ▪ Children more vulnerable due to immature immune system  
▪ Less fluid reserves in cases of infectious vomiting/diarrhea  
▪ Children more likely to become infected due to poorer hygiene and more hand-to-mouth contact |
| **Manmade Disasters: CBRNE** | Nerve Agents | ▪ Types of agents  
  ▪ Sarin (ex. 1995 Japanese subway attack)  
  ▪ VX  
  ▪ Tabun  
  ▪ Soman  
▪ Liquid or gas  
▪ Routes: inhaled or absorption through skin (some healthcare workers in the Japanese subway Sarin attack were off-gassed by liquid nerve agent from victim’s clothing; this shows the important of decontamination of victims with unknown exposures and working in well-ventilated space)  
▪ Mechanism  
  ▪ Acts of blocking enzyme (Acetylcholine esterase) that breaks down acetylcholine (Ach) at neuromuscular junction. Leads to over-stimulation of nervous system |
<table>
<thead>
<tr>
<th>Disasters</th>
<th>Specific Type</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nerve Agents</td>
<td></td>
<td>▪ Symptoms:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▷ Muscarinic receptor effects: “SLUDGEM” symptoms (Salivation, Lacrimation, Urination, Defecation, GI upset, Emesis, Miosis (pupil constriction)) – 90% of receptors are this type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▷ Nicotinic effects: Muscle fasciculation (twitching), seizure, weakness, apnea: 10% of receptors are this type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Treatment: use antidotes if SLUDGEM symptoms present (do not sue antidotes if symptoms are only constricted pupils/mild rhinorrhea)</td>
</tr>
</tbody>
</table>

**Antidotes**

**Antropine**

- Atropine works by blocking post-synaptic receptor from Ach. Reverses SLUDGEM symptoms
- Pediatric dose: 0.05 mg/kg IV/IM/IO repeat q 5-10 minutes until SLUDGEM symptoms start improving
- If out of atropine, alternatives can be used
  - Glycopyrrolate
    - Anti-sialagogue
    - Parasympatholytic
    - Does not cross blood-brain barrier, therefore not helpful with CNS effects of agent
  - Scopolamine
    - Causes deep sedation as side effect

**2-PAM (a.k.a. pralidoxime)**

- 2-PAM acts by removing nerve agent from Ach-esterase.
- “Aging” is time it takes for nerve agent to bind covalently (permanently) with Ach-esterase. Different agents have different aging times that range from seconds to hours. After an agent’s toxic effects
- Pediatric dose: 50 mg/kg (2g max/hr) IV or IM
- Autoinjectors (Mark I): dose is 2mg atropine, 600 mg 2-PAM (use one kit in kids 3-7 yrs, 2 kits for > 8 yrs)

**Supportive Treatments**

- Respiratory support
  - Beta agonists (albuterol)
Disasters  Specific Type  Explanation

Nerve Agents

- Oxygen
- Ventilatory support: Expect high pressures due to airway resistance (50-70 cm H2O)
  - Seizure Control
  - Benzodiazepines are drug class of choice
    - Midazolam 0.15-0.2 mg/kg IM or IV (max 5 mg/dose)
      - less apnea if used IM (slower absorption)
    - Diazepam 0.05-0.3 mg/kg/dose PR or IV
    - Lorazepam 0.05-0.2 mg/kg IV or IM

Pediatric Consideration
- Small mass means smaller doses are lethal
- Higher respiratory rate: Higher dose received
- Smaller airways, larger tongue: Increased risk of obstruction from bronchorrhea
- Smaller intravascular volume: Increased effects from V/D losses
- Immature blood-brain barrier: Increased absorption of agent into CNS
- Less mature metabolic systems in place for natural detox of agents (Paraoxonase: Enzyme responsible for breakdown of nerve agents). At birth levels are ½ those of adults

Manmade Disasters: Toxic Types

CBRNE Industrial Chemicals

- Chlorine
  - Heavier than air, rapidly disperses
  - Bleach-like odor
  - Liquid or gas
  - Inhaled, ingested or absorbed through skin
  - Skin burns, coughing, nose/throat irritation, burns eyes, dizziness, congestion, tissue swelling if ingested, lung damage
  - Symptoms usually appear within minutes of exposure

- Hydrogen cyanide
  - Rapidly disperses
<table>
<thead>
<tr>
<th>Disasters</th>
<th>Specific Type</th>
<th>Explanation</th>
</tr>
</thead>
</table>
| Toxic     | Industrial Chemicals | - Bitter almond odor  
- Liquid or gas  
- Inhaled, ingested or absorbed through skin  
- Skin burns, coughing, nose/throat irritation, blindness, lung damage |

**Pediatric Considerations:**
- Agents heavier than air remain lower to the ground where children tend to be. Accumulation of these agents leads to children being disproportionately affected
- Less pulmonary reserve, higher respiratory rate makes children more severely affected
- Thinner skin leads to higher absorption of agents

<table>
<thead>
<tr>
<th>Manmade Disasters:</th>
<th>Choking Agents Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBRNE Chemical</td>
<td>Phosgene</td>
</tr>
</tbody>
</table>
|                     | - Heavier than air, rapidly disperse  
- Mown hay odor |
|                     | Chemical             |
|                     | - Solid, liquid or gas  
- Inhaled  
- Airway irritation, pulmonary edema, coughing occurs immediately on exposure |
|                     | Chlorine             |
|                     | - Heavier than air, rapidly disperse  
- Bleach odor  
- Liquid or gas  
- Inhaled, ingested or absorbed through skin  
- Skin burns, coughing, nose/throat irritation, burning eyes, dizziness, congestion, tissue swelling if ingested, lung damage  
- Symptoms usually appear within minutes of exposure |

**Pediatric Consideration**
- Agents heavier than air remain lower to the ground where children tend to be. Accumulation of these agents leads to children being disproportionately affected
- Less pulmonary reserve, higher respiratory rate makes children more severely affected
<table>
<thead>
<tr>
<th>Disasters</th>
<th>Specific Type</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toxin</td>
<td>Industrial Chemicals</td>
<td>Thinner skin leads to higher absorption of agents</td>
</tr>
</tbody>
</table>

**Manmade Disasters:**
- **CBRNE Chemicals**
  - **Vesicants - Types**
    - Mustard
    - Lewisite
    - Phosgene

  **Mechanism of action**
    - Burns skin
    - Damages lungs
    - Damages eyes
    - Suppresses bone marrow (3-5 days post exposure)

  **Treatments**
    - Flush skin/eyes with water
    - Topical antibiotics to skin
    - Mydriatics (dilates eyes)
    - Oxygen
    - Bronchodilators
    - Ventilatory support
    - Antidote for Lewisite: BAL (British Anti-Lewisite)- chelates arsenic component

  **Pediatric Considerations**
    - Thinner skin
    - Larger body surface area to volume ratio in children vs. adults: Higher dose received

<table>
<thead>
<tr>
<th>Disasters</th>
<th>Specific Type</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Irritants</strong></td>
<td>CBRNE</td>
<td></td>
</tr>
</tbody>
</table>

**Pediatric Considerations**
- Thinner skin
- Larger body surface area to volume ratio in children vs. adults: Higher dose received
<table>
<thead>
<tr>
<th>Disasters</th>
<th>Specific Type</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>- Cyanogen chloride</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Volatility: rapidly disperse</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Odor: bitter almonds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Mechanism: interrupts electron transport chain in mitochondria, depleting body of energy on a cellular level</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Symptoms: Gasping for air, frothing, vomiting, loss of consciousness, death (occurs within seconds to minutes of exposure)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Treatment</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- If breathing:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Remove clothing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Move to well-ventilated area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Oxygen</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- IV Fluids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- If not breathing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Remove clothing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Move to well-ventilated area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Oxygen</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Advanced airway (intubated or bag-valve mask ventilation)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Antidotes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Amyl nitrite pearls: Bag ventilate pearls into patient after crushing into a gauze</td>
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<tr>
<td></td>
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<td>- Sodium nitrite: 0.2-0.3 mg/kg IV (max 300mg)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Sodium thiosulfate: 1.65 mg/kg U IV</td>
</tr>
<tr>
<td>Manmade Disasters: CBRNE</td>
<td>Class A Biological Agents</td>
<td>- Anthrax</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- <strong>Inhalational</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Most likely form of terrorism</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- No person-to-person spread from respiratory droplets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Flu-like illness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- CXR with wide mediastinum</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Treatment: Ciprofloxacin, doxycycline (amoxicillin if susceptible) x 60 days</td>
</tr>
<tr>
<td>Disasters</td>
<td>Specific Type</td>
<td>Explanation</td>
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</tr>
<tr>
<td>Class A Biological Agents</td>
<td></td>
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</tr>
</tbody>
</table>

- Vaccine available
- Treat exposures with 7-10 days of oral antibiotics while monitoring for symptoms and vaccination
- Skin infection
- Gastrointestinal

- **Plague**
  - Pneumonic
    - Most likely form of intentionally spread disease
    - Person-to-person spread via droplets possible
    - Symptoms: Cough, hemoptysis, sepsis, multi-organ failure, disseminated intravascular coagulation (DIC)
    - Treatment: Streptomycin, gentamicin
  - Septicemic
    - Symptoms: Fevers, low blood pressure and shock

- **Tularemia**
  - Pneumonic
    - Symptoms: Fever, myalgias, headache, cough → rapidly progressing respiratory failure
    - Treatment: Streptomycin
    - No person-to-person transmission via droplets
  - Septicemic
    - Symptoms: Fever, nausea, vomiting, diarrhea, hepatosplenomegaly, sepsis, multi-organ failure
    - Treatment: Streptomycin
    - No person-to-person transmission via droplets

- **Ulceroglandular**: most common form of natural disease
  - Septicemic

- **Smallpox**
  - Symptoms: Malaise, fever, vomiting, headache, backache followed by typical rash (centrifugal: face/arms/legs → trunk)
  - Treatment: None proven, anti-virals, immunoglobulin experimental
<table>
<thead>
<tr>
<th>Disasters</th>
<th>Specific Type</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manmade</strong></td>
<td><strong>Class A</strong></td>
<td>Prevention of spread: “Ring” vaccination recommended</td>
</tr>
<tr>
<td><strong>Disasters:</strong></td>
<td><strong>Biological</strong></td>
<td></td>
</tr>
<tr>
<td><strong>CBRNE</strong></td>
<td><strong>Agents</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Biological</strong></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>▪ Hemorrhagic fever</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Symptoms: Fever, rash, hypotension, bleeding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Treatment: Supportive, experimental: ribavirin (anti-viral)</td>
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<tr>
<td></td>
<td></td>
<td>▪ Very infectious: Double glove, gown mask</td>
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<tr>
<td></td>
<td></td>
<td>▪ Botulism</td>
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<tr>
<td></td>
<td></td>
<td>▪ Mechanism: Toxin inhibits release of acetylcholine from presynaptic terminal</td>
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<tr>
<td></td>
<td></td>
<td>▪ Types: Infant botulism: baby ingest pre-formed toxin</td>
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<tr>
<td></td>
<td></td>
<td>▪ Food borne: Spore present in poorly canned foods ingested</td>
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<td></td>
<td></td>
<td>▪ Wound: Spores/toxin directly invade open wound</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Airborne: Not naturally occurring; would be presumed to be terrorism if occurred. Easily deactivated by water, process plants, and heat</td>
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<tr>
<td></td>
<td></td>
<td>▪ Symptoms: Descending weakness</td>
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<tr>
<td></td>
<td></td>
<td>▪ Treatment: Botulinum anti-toxin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Supportive Care: Ventilation</td>
</tr>
<tr>
<td></td>
<td><strong>Class B</strong></td>
<td>Less easily spread, lower morbidity/mortality</td>
</tr>
<tr>
<td><strong>Biological</strong></td>
<td><strong>Agents</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Brucellosis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Viral encephalitides</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Ricin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Staph enterotoxin B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Food/water borne pathogens</td>
</tr>
<tr>
<td><strong>Manmade</strong></td>
<td><strong>Types of Radiation</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Disasters:</strong></td>
<td><strong>Radiation</strong></td>
<td></td>
</tr>
<tr>
<td><strong>CBRNE</strong></td>
<td><strong>Nuclear</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Ionizing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ High frequency radiation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Does damage to biological tissues (DNA mutation)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Alpha</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ 2 protons, 1 neutron, usually naturally occurring</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Penetrates only depth of piece of paper, so external exposure not harmful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ Damages if ingested or inhaled (polonium on Russian journalist in 2007)</td>
</tr>
<tr>
<td>Disasters</td>
<td>Specific Type</td>
<td>Explanation</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| Manmade Disasters: CBRNE | Types of Radiation | ▪ Beta  
▪ Comes from radionuclides used in medicine, or byproduct of nuclear reactor  
▪ Gamma/x-rays  
▪ Emitted from radioactive particles  
▪ Penetrates deeply through body tissues  
▪ Neutrons  
▪ Powerful, rare  
▪ Emitted after nuclear detonation  |
| Radiation/Nuclear | Sources of Radiation | ▪ Intentional  
▪ “Dirty bomb”: radioactive dispersal device  
▪ Damage of nuclear facility releasing nuclear waste into environment  
▪ Detonation of nuclear weapon  
▪ Unintentional  
▪ Power plan disaster (Chernobyl, Three-Mile Island)  |
| | Mechanisms of Action | ▪ External  
▪ Exposure  
▪ Contamination  
▪ Internal  
▪ Ingestion  
▪ Inhalation  |
| | Effects of radiation | ▪ Short term (days → weeks post exposure)  
▪ Nausea/vomiting/diarrhea  
▪ Bone marrow suppression  
▪ Burning of skin  
▪ Long term (weeks → months/years post exposure)  
▪ Cancer risk  
▪ Psychological injury  |
| | Treatments/Management | ▪ Issue protective clothing and dosimeters to staff  
▪ Control ventilation  
▪ Minimize time of exposure: evacuate early  
▪ Maximize shielding  
▪ Maximize distance from epicenter of release of radioactive material  
▪ Decontamination those exposed  
▪ Strip naked  |
<table>
<thead>
<tr>
<th>Disasters Specific Type</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>❖ Soap/water</td>
</tr>
<tr>
<td></td>
<td>❖ Debride if radioactive material embedded in skin</td>
</tr>
<tr>
<td></td>
<td>❖ Perform surgery, in needed, within 48 hrs of exposure before bone marrow suppression ensues and impairs immunity and healing ability</td>
</tr>
<tr>
<td></td>
<td>❖ Potassium iodide (KI)</td>
</tr>
<tr>
<td></td>
<td>❖ Use in exposure to radioiodines (common with nuclear reactor incidents)</td>
</tr>
<tr>
<td></td>
<td>❖ Use ASAP after exposure or expected exposure</td>
</tr>
<tr>
<td></td>
<td>❖ Floods thyroid with non-radioactive iodine protecting from thyroid cancer</td>
</tr>
<tr>
<td></td>
<td>❖ Protection lasts 24 hrs, so repeated dosing may be needed if ongoing exposure occurs</td>
</tr>
</tbody>
</table>

### Potassium Iodide Dosing

Please pay attention to the number of teaspoonfuls recommended when using a potassium iodide 65 mg tablet as it is different from the number of teaspoonfuls given when using a potassium iodide 130 mg tablet.

**Tablet:** Recommended doses of KI for children and infants with predicted thyroid radioactivity exposures equal to or greater than 5 cGy, using 65 mg tablet preparations.

<table>
<thead>
<tr>
<th>If your child is:</th>
<th>Give child this amount of potassium iodide (KI) *</th>
<th>Which is</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between 4 and 12 years old</td>
<td>8 teaspoonfuls (NOT tablespoonfuls)</td>
<td>65 mg of potassium iodide (KI)</td>
</tr>
<tr>
<td>Over 1 month through 3 years</td>
<td>4 teaspoonfuls (NOT tablespoonfuls)</td>
<td>32.5 mg of potassium iodide (KI)</td>
</tr>
<tr>
<td>An infant from birth through 1 month</td>
<td>2 teaspoonfuls (NOT tablespoonfuls)</td>
<td>16.25 mg of potassium iodide (KI)</td>
</tr>
</tbody>
</table>


**Pediatric Considerations**

- Higher breathing rates: Higher dose inhaled
- Fallout settles to ground where children are: Higher
<table>
<thead>
<tr>
<th>Disasters</th>
<th>Specific Type</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manmade Explosives</td>
<td></td>
<td>exposure</td>
</tr>
<tr>
<td>Disasters: CBRNE</td>
<td></td>
<td>- Radioactive iodine collects in human and cow milk, which children are exposed to in proportionally higher amounts due to diet</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Greater number of dividing cells as they grow makes for increased risk of mutation of DNA</td>
</tr>
<tr>
<td>Explosive</td>
<td></td>
<td>- Mental health vulnerability increased compared with adults</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Decontamination of children is challenging</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Locations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Mortality: Structural collapse &gt; confined space &gt; outdoor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- High order</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Explosion faster than speed of sound</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Creates pressure wave that damages organs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Low order</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Explosion slower than sound</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Damage of tissues by burning</td>
</tr>
<tr>
<td><strong>Explosives can be attached to other types of weapons (bio, nuclear, chemical)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Order Injuries</td>
<td>Primary – Damage caused by pressure wave (detonation)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Affects air-fluid interfacing organs most commonly</td>
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<td></td>
<td>Ears</td>
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<td>- Tympanic membranes (TM’s) rupture at relatively low pressure</td>
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<td>- If TM’s intact, less likely to have other severe primary blast injury</td>
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<td></td>
<td>- Symptoms</td>
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<tr>
<td></td>
<td></td>
<td>- Hearing loss</td>
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<td></td>
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<td>- Tinnitus</td>
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<td></td>
<td>Lungs</td>
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<td></td>
<td>- Most common cause of mortality in high order explosions</td>
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<td></td>
<td></td>
<td>- Hemo/pneumothorax</td>
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<td>- Pulmonary contusion</td>
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<td>- Systematic air embolism</td>
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<tr>
<td></td>
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<td>- Pneumomediastinum</td>
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<tr>
<td>Disasters Type</td>
<td>Specific Type</td>
<td>Explanation</td>
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| Manmade Disasters | High Order Injuries | o Respiratory distress  
| CBRNE Explosive | o Cough  
| | o Hemoptysis  
| | o Hypoxemia  
| | Intestines  
| | ▪ Perforated viscus can present delayed with abdominal pain  
| | Brain  
| | ▪ Can prevent with headache, alteration of mental status or appear like behavioral problem  
| | ▪ Usually occurs when patient was in close proximity to epicenter of blast  
| | Eye  
| | ▪ Presents with changes in vision, eye pain, blurry vision  
| Secondary – Damage caused by shrapnel striking body | Penetrating Injury > blunt injury  
| | ▪ Lacerations (check front/back of patient  
| | ▪ Extremity amputation: Poor prognosis  
| | ▪ Eye injury: 15 percent  
| Tertiary – Damage caused by victim’s body striking object | Blunt injury > penetrating injury  
| | ▪ Fractures  
| | ▪ Contusions  
| Quaternary: Any other injury from explosive burns | Burns  
| | ▪ Assess percentage burn surface area (BSA) burned with second/third degree burns  
| | ▪ Rule of Nines  
| | ▪ Pediatric victim’s palm: One percent BS  
| | Smoke Inhalation  
| | ▪ Look for signs of upper airway burn (singed nasal hair, soot around perioral area  
| | ▪ Building collapse  
| | ▪ Very high mortality  
| | Crush injury  
| | ▪ Risk of acute renal failure (ARF  
| | ▪ Risk of electrolyte abnormalities from ARF
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| Manmade Disasters: CBRNE Explosive | High Order Injuries | Compartment syndrome  
  - Assess compartments in extremity crush injury, if bleeding into compartments  
  - Pressure >30 mm Hg: Likely need for fasciotomy  
  
  **A note on Compartment Syndrome**  
  Pressure assessment may not be possible. Other options for assessing compartment syndrome include:  
  1. Pain in extremity disproportionate to injury with acute or passive movement of hand or foot  
  2. Loss of distal pulses  
  3. Pallor  
  4. Paresthesia of limb  
  - Exacerbation of existing medical condition |
| Low Order Injuries | Caused by burning of layers of tissue (deflagration) | Burns  
  - Smoke inhalation  
  - Penetrating trauma  
  - Blunt trauma |
| Treatment of Injuries | Primary Ears | Tympanic membranes (TM’s) rupture: no specific treatment |
| | Lungs | * Any pulmonary injury may require advanced airway or mechanical ventilation if severe enough  
  - Hemo/pneumothorax: Chest tube, oxygen  
  - Pulmonary contusion: Oxygen, +/- chest tube  
  - Systemic air embolism  
  - Pneumomediastinum: Oxygen |
| | Intestines | Perforated viscous: antibiotics, surgical repair perforated intestine |
| | Brain | Monitor intracranial pressure  
  - Elevate head of bed  
  - Maintain normal pCO2  
  - Neurosurgical release of intracranial bleed if needed/possible |
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| **Eye**   |               | - Globe rupture: Antibiotics, ophtho consultation  
- Hyphema: Ophtho consultation  
- Retinal detachment: Ophtho consultation |
| **Secondary: Penetrating injury > blunt injury** | | - Pneumo/hemothorax: Chest tube, Oxygen  
- Treat lacerations as dirty wounds  
  - Control bleeding  
  - Tetanus  
  - Delayed closure if possible  
  - Consider retained foreign body before closure  
- Extremity amputation: Control bleeding, antibiotics, orthopedic consultation |
| **Tertiary: Damage caused by victim’s body striking object** | | - Blunt > penetrating injury  
  - Fractures: Stabilize by splinting unless neurovascular compromise  
  - Contusions – r/o internal bleeding  
  - Internal organ/viscous damage |
| **Quaternary: Any other injury from explosive** | | - Burns  
  - Stop burning process  
  - Evaluate for circumferential burns which could impede blood flow to an area  
  - Topical antibiotics with non-stick dressing  
  - Fluid resuscitation  
  - Parkland formula based on estimated BSA burned  
    - # of ml = 4 x % of body surface area burned x weight (kg)  
      - Half of the volume administered over the first 8 hours  
      - Remaining half of volume administered over the following 16 hours  
  - Intubate early if signs of upper airway obstruction are present  
  - Administer pain medication |
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| **Manmade Disasters:** CBRNE Explosive | Treatment of Injuries | Smoke inhalation
| | | o Oxygen
| | | o Beta agonist trial
| | | o Check CO level
| | | o Maintain airway if signs of airway burn (singed nose hair, soot periorally, carbonaceous sputum, hoarseness, noisy breathing)
| | | Building collapse
| | | Crush injury
| | | o IV hydrate
| | | o Watch for hyperkalemia from intracellular release
| | | o Mannitol or Lasix once UOP established
| | | o Assess kidney function/need for dialysis
| | | Exacerbation of existing medical condition (ex. Asthma attack triggered by smoke)
| | Compartment Syndrome | Compartment Syndrome
| | | o Assess compartments in extremity crush injury, if bleeding into compartments
| | | o Pressure > 30 mm Hg: Likely need for fasciotomy

**A note on Compartment Syndrome**
Pressure assessment may not be possible. Other options for assessing compartment syndrome include:
1. Pain in extremity disproportionate to injury with acute or passive movement of hand or foot
2. Loss of distal pulses
3. Pallor
4. Paresthesia of limb

| Pediatric Vulnerabilities | Less circulating volume: Increased risk of exsanguinations |
| | Less protection of internal organs b/c less protection from ribs |
| | Larger head: More likely head trauma |
| | Psychological |
BLAST INJURY/TRAUMA

http://www.bt.cdc.gov/masscasualties/explosions.asp
http://www.bt.cdc.gov/masscasualties/blastessentials.asp

Key points:

The surge created by an explosion (industrial, accidental, IED, VBIED, etc) can be rapid and devastating. In addition to preparing for a very rapid surge of patients, the following incident specific considerations are vital:

- Be cautious of unexploded ordinance (UXO) in/on patients

- As with any other possible/confirmed terrorism event, scene safety is paramount

- In addition to injury/trauma, patient may have partial to complete hearing loss & not readily follow commands

Blast Injuries: Essential Facts

Key Concepts

- Bombs and explosions can cause unique patterns of injury seldom seen outside combat
- Expect half of all initial casualties to seek medical care over a one-hour period
- Most severely injured arrive after the less injured, who bypass EMS triage and go directly to the closest hospitals
- Predominant injuries involve multiple penetrating injuries and blunt trauma
- Explosions in confined spaces (buildings, large vehicles, mines) and/or structural collapse are associated with greater morbidity and mortality
- Primary blast injuries in survivors are predominantly seen in confined space explosions
- Repeatedly examine and assess patients exposed to a blast
• All bomb events have the potential for chemical and/or radiological contamination
• Triage and lifesaving procedures should never be delayed because of the possibility of radioactive contamination of the victim; the risk of exposure to caregivers is small
• Universal precautions effectively protect against radiological secondary contamination of first responders and first receivers
• For those with injuries resulting in no intact skin or mucous membrane exposure, hepatitis B immunization (within 7 days) and age-appropriate tetanus toxoid vaccine (if not current)

Blast Injuries
• Primary: Injury from over-pressurization force (blast wave) impacting the body surface
  o TM rupture, pulmonary damage and air embolization, hollow viscous injury
• Secondary: Injury from projectiles (bomb fragments, flying debris)
  o Penetrating trauma, fragmentation injuries, blunt trauma
• Tertiary: Injuries from displacement of victim by the blast wind
  o Blunt/penetrating trauma, fractures and traumatic amputations
• Quaternary: All other injuries from the blast
  o Crush injuries, burns, asphyxia, toxic exposures, exacerbations of chronic illness

Primary Blast Injury
• **Lung Injury**
  - Signs usually present at time of initial evaluation, but may be delayed up to 48 hrs
  - Reported to be more common in patients with skull fractures, >10% BSA burns, and penetrating injury to the head or torso
  - Varies from scattered petechiae to confluent hemorrhages
  - Suspect in anyone with dyspnea, cough, hemoptysis, or chest pain following blast
  - CXR: “butterfly” pattern
  - High flow O2 sufficient to prevent hypoxemia via NRB mask, CPAP, or ET tube
  - Fluid management similar to pulmonary contusion; ensure tissue perfusion but avoid volume overload
  - Endotracheal intubation for massive hemoptysis, impending airway compromise or respiratory failure
    - Consider selective bronchial intubation for significant air leaks or massive hemoptysis
    - Positive pressure may risk alveolar rupture or air embolism
  - Prompt decompression for clinical evidence of pneumothorax or hemothorax
  - Consider prophylactic chest tube before general anesthesia or air transport
- Air embolism can present as stroke, MI, acute abdomen, blindness, deafness, spinal cord injury, claudication
  - High flow O2; prone, semi-left lateral, or left lateral position
  - Consider transfer for hyperbaric O2 therapy
- Abdominal Injury
  - Gas-filled structures most vulnerable (esp. colon)
  - Bowel perforation, hemorrhage (small petechiae to large hematomas), mesenteric shear injuries, solid organ lacerations, and testicular rupture
  - Suspect in anyone with abdominal pain, nausea, vomiting, hematemesis, rectal pain, tenesmus, testicular pain, unexplained hypovolemia
  - Clinical signs can be initially subtle until acute abdomen or sepsis is advanced
- Ear Injury
  - Tympanic membrane most common primary blast injury
  - Signs of ear injury usually evident on presentation (hearing loss, tinnitus, otalgia, vertigo, bleeding from external canal, otorrhea)

Other Injury
- Traumatic amputation of any limb is a marker for multi-system injuries
- Concussions are common and easily overlooked
- Consider delayed primary closure for grossly contaminated wounds, and assess tetanus immunization status
- Compartment syndrome, rhabdomyolysis, and acute renal failure are associated with structural collapse, prolonged extrication, severe burns, and some poisonings
- Consider possibility of exposure to inhaled toxins (CO, CN, MetHgb) in both industrial and terrorist explosions
- Significant percentage of survivors will have serious eye injuries

Disposition
- No definitive guidelines for observation, admission, or discharge
- Discharge decisions will also depend upon associated injuries
- Admit 2nd and 3rd trimester pregnancies for monitoring
- Close follow-up of wounds, head injury, eye, ear, and stress-related complaints
- Patients with ear injury may have tinnitus or deafness; communications and instructions may need to be written

This fact sheet is part of a series of materials developed by the Centers for Disease Control and Prevention (CDC) on blast injuries. For more information, visit CDC on the Web at: emergency.cdc.gov/BlastInjuries