Electrical and Radiation Injuries

Lecture 20

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Outcomes

At this lecture's completion, the learner will be able to:

- Integrate pathophysiological principles with clinical presentations of electrical and radiation injuries
- Discuss the treatment of electrical burns
  - With attention to methods of preventing potentially life-threatening complications
- Discuss a brief general prognostic and treatment considerations in the management of radiation injuries

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Electrical Injuries - Epidemiology

- Young children
  - Household appliances; sockets; cords
- Adolescent males
  - Risk-taking behaviors
- Workers exposed to electrical hazards
  - Utility workers
  - Appliance workers
- 3-5% of burn admissions involve electrical burns
- The use of GFCIs (ground fault *circuit interrupters*) may reduce home electrocutions. GFCIs may be installed in home circuits in bathrooms and kitchens - where household members or workers may be at risk for becoming grounded

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Electrical Injury Pathophysiology

- Tissue damage by electric current passing through the tissue (destruction by : depolarizing ; heating ; puncturing holes in cell)
- Resemble crush injury
  - Nerves ; blood vessels
  - Muscles (myonecrosis, myoglobinemia, and myoglobinuria)
- Exit wound and entrance wounds
- Size of injury : no correlation with degree of damage
- Traumatic injuries are frequent (C- spine)
- Cardiac arrhythmias
- Fetal injury
- Current through brain: LOC instantly

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Electrical Injury Determinants

FYI

- Tissue resistance generates thermal damage
  V = Current x Resistance
  Increased resistance = increased heat [damage]
  Increased current = increased damage. Current more damaging than voltage ; eg TASER: high V (10,000) ; no current
- Tissue risk or frequency is influenced by decreased tissue resistance [how easy is it for the current to flow]:
  - Nerve > blood > tendon > fat > bone
- Tissue severity is influenced by increased tissue resistance [how hard is it for current to flow; slow flow = greater burn]:
  - Bone > fat > tendon > blood > nerve
  - Bone / tendons heat up and coagulate
  - Neuro and vascular PE may underestimate the injury

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Injury Determinants

- AC is worse than DC
- AC
  - Wound: entrance = exit
  - Can't let go [fast enough]
    (Muscle cycles at same rate as the current)
  - Household current high voltage AC
    - Washer; refrigerator; dishwasher
      (often involving H_2O)
- DC
  - Victim thrown (additional trauma)
  - Wound: exit > entry wound
    (as if launched by the exit wound)

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Electrical Injuries Complications

- Cardiovascular
  - arrhythmias
- Neuro
  - seizures... peripheral neuropathy
- Respiratory
  - arrest
  - pulmonary contusion
- Renal
  - ARF secondary to rhabdomyolysis / myoglobinuria
    - With secondary ATN (acute tubular necrosis) and renal failure
- MS
  - compartment syndrome
  - long bone fractures
  - spinal fractures

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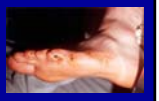
High Voltage Electrical Injury

- High voltage : >1000 V
  > 600 : significant risk:
  - Death
  - Tissue destruction
- US power lines:
  - 7620 V
- House- lines
  - Entry: 220 V
  - Socket: 220 V
- High voltage injury
  - Burns
  - Victim thrown
  - Muscle contracture
  - Fractures, dislocations
  - May resemble a crush injury
  - AC/DC : arrhythmias; arrest: ***asystole***

High tension injury characteristics :
- typical high volt ***entrance*** wound

exit wound: may look innocuous; pathognomonic of current injury



photos: www.burnsurgery.com/.../bsinitialsec9.htm

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Low Voltage Electrical Injury

- low voltage (<1000 V)
- More common
- Burns: minor (at 110 V)
  - 50% of low voltage deaths have ***NO*** burns
- low voltage AC cardiac deaths:
  - ***VF*** ; not initially asystole. Other arrhythmias: rare
- Adult
  - adult who becomes grounded while touching an appliance or other object that is "hot"
- Pediatric: children who bite extension cords
  - Oral commissure
  - Risk of erosion into labial artery

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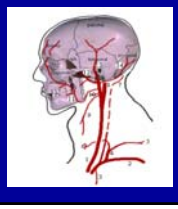
Oral Commissure Burn and Labial Artery Hemorrhage

- Death by loss of:
  - A, B
  - C
- Tx: … and direct pressure :
  - find the location of the facial artery(s) crossing the mandible
  - May have to apply bilateral pressure (because of the midline anastomosis of the L + R labial arteries)



Picture 1:en.wikipedia.org/wiki/Inferior_labial_artery
Picture 2: http://www.med.mun.ca/anatomyts/head/carotid.gif

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Electrical Injuries: Treatment

CABCDE / CO_2M_3EBIG
IV NS 20 ml / kg
Treat
- Rhabdomyolysis
  - Sodium Bicarbinate 1 mEq/kg IV for hyperkalemia (just as you would in a crush injury)
  - Mannitol or furosemide for elevated CPK (to prevent acute tubular necrosis and ARF due to myoglobinuria)
- Arrhythmias
- Seizures
- Trauma
  - Dislocations; fractures

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Admission Criteria For Electrical Injury Patients

- Any high voltage (>600 V)
- Any patient with systemic complications
  - CV
  - Neuro
    - ALOC, weakness, extremity abnormality
- Any suspected foul play

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Radiation Exposure and Injury

- Possible Settings
  - Nuclear power plants
  - Medical imaging (xray) materials
  - Terrorism potential
    - Major radiation exposure in association with a terrorist attack is unlikely [1].

1. Major Radiation Exposure – What to Expect and How to Respond, Mettler, FA, et al *N Engl J Med*, 346(20): 1554, May 16, 2002

See also: http://www.bt.cdc.gov/radiation/#clinicians; http://www.bt.cdc.gov/radiation/dirtybombs.asp;

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Radiation Terminology

Common terms

- Alpha
  - Lowest energy, slowest moving
  - Can penetrate 0.1 mm into tissue
- Beta
  - Penetrate clothing but not through a thin layer of metal (foil)
  - Penetrate 8 mm to a few cm (burns)
- Gamma
  - xray
  - penetrate deeply (***acute radiation sickness***)
- Neutron (5 x gamma)
  - Near reactor core; not at periphery [medic exposure unlikely]
  - [quick kill at Chernobyl, 26th April 1986. 20,000 R /hr - lethal dose is +/- 500 R/hr over 5 hours. Thus, unprotected workers had a fatal dose within minutes]

Other terms (FYI):

- Gray: amt of energy deposited in tissues
- Rads: 1 Gray = 100 Rads
- Rems: Rads x "quality factor" [how much destruction the combination caused]
- Seiverts: Grays x "quality factor"

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Radiation Injury

Early injury / early symptomatology

- Most susceptible - high turnover cells:
  - ***Most rapidly dividing***:
    - Bone marrow and blood
    - Intestinal mucosa (a dose of 1 Gy will cause N,V,D)
  - Hair
  - Skin
    - Similar to thermal burns, but ***appear days later***
    - ***6 Gy*** : erythema (median lethal dose: 4.5 Gy)
      - 100% mortality w/in 30 days
    - 10 Gy : sloughing
- Least susceptible - low turnover cells:
  - Brain
  - Muscle

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Determinants of Radiation Injury

- Time : duration of exposure
- Distance
  - Doubling the D will decrease the radiation dosage by a factor of four (the inverse square law)
- Shielding
- Irradiated cells
  - WBCs short half life

    48 hr lymphocyte count
    - > 1200 : good prognosis
    - 300- 1200 : possibly lethal
    - < 300 : lethal; soon
  - Solid organ tumors may occur years later

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Radiation Injury Categories

Categories

- "Clean"
  - Over and done with
  - Internal
    - eg., S/P dental X Ray
  - No cross contamination
- "Dirty"
  - External contamination
  - On-going exposure
    - eg., nuclear waste truck MVA and spill
  - Can spread to local environment

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Radiation Injury

Clinical Features

- Active radiation syndrome (not universal term)
  - due to whole body gamma irradiation
    - ***N, V : sensitive indicators***
      - within hours

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Radiation Injury Treatment

- "Clean"
  - Supportive
  - No risk of contamination
- "Dirty"
  - Contamination precautions
    - Time
    - Distance
    - Shielding
  - Consider "scoop + go"
    - eg., no full immobilization
  - Stable patients can be decontaminated prior to ED treatment

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Radiation Exposure Procedures and Decontamination

- Evacuation from the scene to prevent new victims
- Determine type of exposure
- Decontaminate prior to ED
  - For dirty contamination: removal of clothing will eliminate 90% of the contamination
  - Limit the spread to the ED
  - Wrapping victims in sheets will minimize the spread [1]
- Separate hospital entrance
- Soap and water ; do not abrade the skin
- Closed system of drainage and ventilation
- Potassium iodide (prevents radioactive I uptake by the thyroid gland)

1. Mettler . Ibid

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Summary

- Some of the clinical presentations of electrical injury
  - High voltage : >1000 V --> : ***asystole***
  - Low voltage AC --> ***VF*** ; not initially asystole
  - 50% of low voltage deaths have ***NO*** burns
- Complications anticipated in electrical injuries
  - IV NS, bicarb, mannitol may be indicated
  - direct pressure on the mandible may be indicated
- Radiation terminology , ***acute radiation sickness***, and which tissues are most affected (***CTX-like***), predictors of a bad outcome after exposure(***6 Gy***), and how time and distance as factors affecting injury (***inverse square***)
- Treatment considerations in radiation exposure (***KI***)

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