

2009 EMS Symposium A Shocking Experience

2009 EMS Symposium
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Course Objectives

Upon Completion of this Lecture:

- **The participant will have insight on the facts associated with electrocution.**
- **The participant will have knowledge on how the body reacts to electrocution.**
- **The participant will have an understanding of the initial treatment of electrocution.**
- **The participant will be able to describe the management of a patient with electrocution.**
- **The participant will have knowledge on the long - term effects on the body with electrocution.**



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Outline

- Introduction to electrocution.
- The body versus electricity. Who will win!
- Initial treatment to electrocution.
- Management of electrocution.
- Long - term effects of electrocution.
- CASE STUDY!
- Q & A



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Introduction to Electrocution

- At least a 1000 people each year are electrocuted
- This accounts for 3% of all burns in US.
- Electricity Professionals are at high risk and males (age 20-25).
- Mortality varies depending on current pathway.



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Introduction to Electrocution

- *Characteristics of Electricity*

- Factors Determining Severity of Injury

- Voltage and Amperage
 - Resistance of internal body structure / tissue
 - Type and pathway of current
 - Duration and intensity of contact



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Introduction to Electrocution

- *Amperage*

- The number or volume of electrons flowing between 2 potentials
- Measures the rate of flow of electricity or how much electricity is forced through the conductors in a given length of time
- We measure the rate of water flow in gallons per minute. Electricity is measured in amperage.
- A can opener has 1.5 amps



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Introduction to Electrocution

- The force with which the electrical movement occurs.
- Measures the pressure or force that causes electricity to flow through conductors.
- Water won't flow without a pressure in back of it. Volts is that "pressure" for electricity.
- A typical household outlet has 110 volts or 220 volts

Both high and low voltage can cause injury and death.

Introduction to Electrocution

- *Type of Current (AC or DC)*
 - The type of current can also help determine the significance of the injury.
 - There are 2 types:
 - ❖ Alternating Current
 - ❖ Direct Current



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Introduction to Electrocution

- *Direct Current*
 - Flows in one direction only
 - Usual form is a battery
 - A flashlight battery has 1.5 volts
 - Does not usually produce tetany (muscle contraction)



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Introduction to Electrocution

- *Alternating Current*

- Alternates the direction it flows in a wire, usually from a generator
- Most dwelling in US have AC
- Causes tetany contractions of muscles, freezing the victim to the source
- A household outlet has 120 or 220 volts
- High voltages (>500) can cause v-fib or asystole)



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Introduction to Electrocution

- *Which is more dangerous:
AC or DC?*
- It is actually the voltage that makes the difference
- AC shock can cause the victim to be “frozen” to the source d/t the tetany, increasing the time of exposure
- To be considered “dangerous,” an electrical source needs not only high voltage (at least 40 Volts), but also the ability to pump a larger electric current.



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Introduction to Electrocution

- *Resistance*

- The degree of resistance to electron flow
- A “current” cannot be established unless it can break through the resistance.
- Electricity enters the body and travels the path of least resistance
- The order of least resistance: nerves, blood vessels, muscles, skin, tendons, fat, and bone
- A “static electricity shock” can contain 20,000 volts



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Introduction to Electrocution

- *Current Pathway*

- When a current pathway is developed, it follows the path of least resistance through the body.
- The current pathway can determine the severity of the injury

Head to Thorax

Hand to Foot

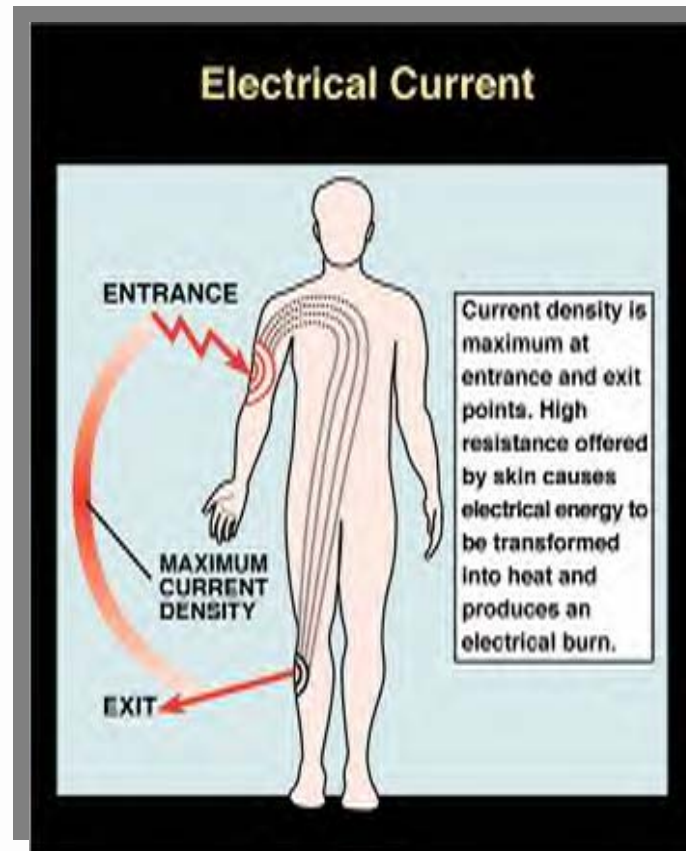
Hand to Hand

Foot to Foot



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Introduction to Electrocution



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Introduction to Electrocution

- *Direct Contact*
 - The person actually becomes part of the circuit
 - Extensive areas of necrosis along the current pathway (following path of least resistance)
 - Entrance and exit wound apparent. (This is no real indication of damage to internal tissue.)
 - Ex. Grabbing a live wire (while grounded)



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Injuries Associated with Electrocution

Systemic

1. Arrhythmias
2. Cardiac arrest
3. Metabolic acidosis
4. Myoglobinuria

Local

1. Direct cellular damage
2. Arterial / venous coagulopathies
3. Healthy tissue devascularization
4. Gross necrosis



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Injuries Associated with Electrocution

- Full thickness exit and entrance wounds (direct contact)
- DC more discrete wounds than AC.
- AC is more explosive.
- Energy traveling through the current path collects at the grounding point, causing significant tissue necrosis along the way, and subsequently causing an explosive exit through the skin
- Burns, charring, blistering



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Injuries Associated with Electrocution

- Whole body may be involved with arc burns
- Areas other than entrance / exit wounds may be effected later due to arterial / venous coagulations

Injuries Associated with Electrocution



Injuries Associated with Electrocution

- V-fib can be seen with **AC** if current pathway crosses through heart
- Cardiac standstill can be seen with **DC** by depolarizing the entire myocardium
- Coronary artery spasm can cause multiple arrhythmias (afib, sinus brady, ventricular or atrial ectopy, SVT, BBB, 1st or 2nd degree heart block) or direct myocardial injury
- Myocardial rupture
- Myocardial damage manifests itself in the same manner as MI or ischemia



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Injuries Associated with Electrocution

- Skull as entry = brain stem injury, leading to respiratory arrest, cerebral hemorrhage, cerebral edema
- The nervous system tissue is an excellent conductor of electrical current, damage is common
- Manifestations: unconsciousness, seizures, decreased LOC, confusion, amnesia



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Injuries Associated with Electrocution

- S/S could be d/t a traumatic head injury from the fall to the ground as well (These patients are TRAUMA patients! Do not get tunnel vision on the electrocution)
- From AC electrocution: tetany around the vertebral column could incur vertebral column instability and a subsequent spinal cord injury
(Think about spinal immobilization)
- Local nerve damage presents as peripheral neuropathies.



Injuries Associated with Electrocution

- Damaged vessels supplying the damaged tissue can cause difficulty with homeostasis in open wounds. Cause poor healing
- Extensive necrosis over vessels may precipitate delayed hemorrhage from large blood vessels
- Arterial thrombosis, DVT, Abdominal Aortic Aneurysm

Injuries Associated with Electrocution

- Submucosal hemorrhage in bowel
- Liver failure, nausea / vomiting, paralytic ileus, ulcerative disease



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Injuries Associated with Electrocution

- Long bone fractures / dislocations and vertebral fractures caused by rigorous tetanic muscle contractions or by the trauma of the fall
- Muscle damage leads to edema formation and possible compartment syndrome requiring escharotomy, may see this within hours of injury.
- Striated muscle (skeletal muscle) damage leads to release of myoglobin

Injuries Associated with Electrocution

- Airway remains priority d/t possible neuro. or cardiac damage possibly precipitating a respiratory arrest. (May not be immediate)
- Tetany from AC can cause laryngospasm.

Injuries Associated with Electrocution

- Acute Renal Failure: direct damage to kidney through electrocution OR from blunt trauma to kidney, OR from myoglobinuria (24 - 48 hours post injury).
- What is myoglobin? A large protein that transports O₂ (found in striated muscles). When these muscles are damaged, the protein is released into the system and can mechanically obstruct the renal tubules. Urine will appear dark, pink, or red. Will cause ARF if not excreted.



Myoglobinuria



Management of Electrocution

Do not allow the gross deformity and burns to distract attention from life-saving interventions

- Airway, spinal immobilization
- Connect to cardiac monitor
- Observe and treat for cardiopulmonary arrest or other cardiac arrhythmias
- Establish IV access (2 large bore)
- Transport to nearest ED for stabilization
(Burn Center considered post stabilization)
- Consider Air Transport



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Management of Electrocution

- **Airway is the primary focus**
- Most patients will require intubation
- Laryngospasm from tetany may occur
- Impaired gas exchange (respiratory acidosis initially leading to metabolic acidosis later) may require sodium bicarbonate (1 amp per liter x 24 - 48 hours)



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Management of Electrocution

- At risk for developing arrhythmias for the first 24 hours post injury
- Baseline 12 lead EKG and continuous thereafter
- Most abnormal complex configurations trend towards restoration towards a normal configuration over a couple weeks
- Measured cardiac enzymes will be initially elevated but are not necessarily indicative of a cardiac etiology



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Management of Electrocution

- Initially 2 large bore IV's LR (preferred) or NS
- It is difficult to assess the area of surface burns because of the deep injury produced along the current pathway. Therefore, using any one of the burn formulas as the only means of determining fluid requirements would be incorrect (Rule of 9's, Parkland's)



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Management of Electrocution

- Essential to maintain higher rates of urine output due to myoglobinuria. Fluid rates should be based on urine output, minimal 50-100 cc/hour, but may need a 100 cc/hr urine output (2 ml/kg/hr for pediatrics). Outputs maintained until urine clear, then a urine output of 30 cc/hr (1 ml/kg/hr for pediatrics) is maintained.
- First 24 hours: may see electrical burn shock d/t decreased capillary integrity



Management of Electrocution

- Fractures / dislocations could occur from tetany around vertebral column or from blunt trauma from fall
- Complete spinal immobilization is necessary for all patients

Management of Electrocution

- Edema within damaged area may create a compartment syndrome, requiring fasciotomy
- Lack of blood flow d/t damaged vessels
- Amputation may be necessary d/t devascularized areas.
- Treat burn wounds as any other burn



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Management of Electrocution



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Management of Electrocution

***Morphine /
Fentanyl for pain
and lots if it!***



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Long term Effects

- Cataracts seen anywhere from 4 months to 3 years post injury
 - Pt may have short term memory deficit (resolves in 4-6 weeks)
 - Ataxia, gait alteration, sensory deficits may improve over time or remain constant



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- Do you need a stretch break?
- ***We will be starting the case study. I don't think you will want to miss it.***

Case Study

- Background information on Phil.
- He has been with the electric company since April 1, 1996. Advanced to lineman position.
- He competed in Lineman competitions and has won first place many times.
- He is married and has 3 small children



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Case Study

- On September 19, 2008 around 12 noon Phil. was completing work on a three phase poll working with 7200 volts.
- Lines are secured in with lag screws.
- He was approximately 40 feet in the air, harnessed to a poll.
- Lag screw pulled out causing a power line to fall on his left shoulder area.



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Case Study

- Steve Clark was in the bucket truck positioned lateral to Phil.
- Power line actually hit Phil twice, the second jolt of electricity inverted Phil into a head down position hanging by his harness onto the pole.



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Case Study

- Steve immediately reached over and positioned himself to pull Phil into to bucket.
- He noted a gurgling noise prior to reaching for him.
- He grabbed both of Phil's arms and pulled him into the bucket.
- He noted that Phil began to moan.



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Case Study

- Steve brought Phil to the ground at that point he was take from the bucket and placed flat on the ground.
- Steve immediately obtained an AED in the event Phil arrested.
- Steve noted that after a few minutes Phil seemed disoriented and stood up, tried walking around.
- When EMS arrived Phil was able to answers questions.



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Scene



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Scene



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Scene



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Case Study



Case Study



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Case Study



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Case Study



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Case Study

- EMS called to scene, there was a delay to call EMS, cell service was poor, a co-worker left to get service and call. .
- Responsive when EMS arrived and in severe pain, and shortness of breath.



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Case Study

EMS Time - Line

- Dunlap Rescue dispatched @ 1228.



Case Study

- En – route @ 1234.



Case Study

- Call for air service
1233 (LG time)



Case Study

- On scene 1240, @ pt. side 1243



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Case Study

- Left scene en – route to LZ @ 1254



Case Study

- Dunlap arrived LZ @ 1258



Case Study

- While awaiting Carilion Life - Guard
- IV 18g. X 2 established.
- IV #1 – running wide open
- IV #2 – TKO
- Morphine 5mg IV @ 1301
- NRB 15/ lpm

Case Study

- LG received request @1245.
- En- route @ 1255



Case Study

- Arrived LZ @ 1314, arrived @ patients' side @ 1316.



LZ Elementary School



LZ Elementary School



LZ Elementary School



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Case Study

- Upon arrival to pt. side, evaluated patient.
- NRB on @15lpm/ continues with severe shortness of breath.
- Due to injuries decision made to RSI on scene.
- Received Lidocaine 120mg @1322
- Received Etomidate 16mg @1323
- Received Succinylcholine 120mg @1324.
- One attempt @ intubation, during the attempt it was evident that his airway was swelling.
- Joint decision made to use LMA.



Case Study

- LMA inserted & airway was confirmed
- Patient already packaged (spinal immobilization) for transport.
- **Fentanyl 100mcg IV**
- **Versed 5mg IV**
- **Zemuron 30mg IV**
- Above given on scene for pain control, sedation and short acting paralytic.



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Case Study

- Patient made ready for transport to a/c.
- Loaded into a/c @ 1345
- In the air and transporting @ 1347.



Case Study Time Frame

- Dunlap Rescue dispatched 1228.
- En – route @ 1234.
- Dunlap Rescue @ patients' side 1243
- LG received request @1245
- Dunlap left scene en – route to LZ @ 1254
- LG en- route @ 1255
- Dunlap arrived LZ @ 1258.
- Arrived LZ @ 1314
- Arrived @ patients' side @ 1316
- Loaded into a/c @ 1345
- In the air and transporting @ 1347.



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“Back Up Aircraft”



“LG 10 Then”



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“LG10 Now”



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Case Study

- Lifted for RMH.
- Unable to get to UVA due to weather.
- En – route to RMH.
- Received 100mcq fentanyl
- Received Versed 5mg
- Received total 1700ml NS IV
- Received all of the above in flight.
- BV – LMA ventilated during flight.



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Case Study

- Evaluation of burns:
- 1°, 2°, 3° to left side face, neck and shoulder.
- 3° to right knee anterior & posterior.
- 3° to left calf area with exit of electricity.
- Burns around his airway.
- Total calculation 30% (1/3 body).
- Parkland formula calculation for Phil – $4\text{ml} \times 85\text{kg} \times 30\% =$
- 1st 8 hours need 5100 ml (760ml/hr)
- Next 16hours need 5100 ml (440ml/hr)



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Case study

- Arrived @ RMH rooftop @1403.
- As a Gold Alert.
- Arrived in trauma room @1405
- Decision made by trauma surgeon best chance of survival of left leg fasciotomy.
- Immediately went to OR within an hour ready for transport to burn center.



Case Study



Case Study

- LG notified patient ready for transport to MCV @1500. UVA closer burn center (they were full)
- In PACU LG was preparing for transport.
- Back – up a/c landed on rooftop and departed immediately.
- Mechanical issue

Case Study

- Sister ship LG 11 was dispatched & en – route to RMH from NRV for flight to MCV.
- Arrived @ RMH 1630.
- Transporting @1707.
- Arrived @ MCV 1816

Case Study

- During flight MCV received 200mcg fentanyl
- Versed 5mg
- Vecuronium 10mg.
- IV total from time of burn until arrival MCV approx. 12,000 cc
- Output approx. 12,000 cc



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Case Study

- Parkland Formula 4ml/kg/% burn (only for 2nd & 3rd degree) - give 50% first 8 hours, the half over the other 16 hours
- Weight 85kg (180 lbs.)
- 1st 8 hours – 760ml/hr
- Total for parkland formula= 5100ml IVF/
1st 8 hours
- Ahead by 7000



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Case Study



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Case Study

- Phil spent 34 days in MCV.
- Phil went through several skin grafts.
- Lost left leg above the knee.
- Concern he would loose right leg, had severe burn to right knee area.
- Severe pain during recovery.
- Types of pain – phantom pain, nerve pain, and muscle pain



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Case Study



Case Study



Case Study



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Case Study



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Case Study



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Case Study



Case Study



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Case Study



Case Study



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Case Study



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Case study

- October 23rd, 2008 left MCV.
- Unfortunately returned within 36 hours for complications. Developed N,V,D possibly from medication for control of pain.



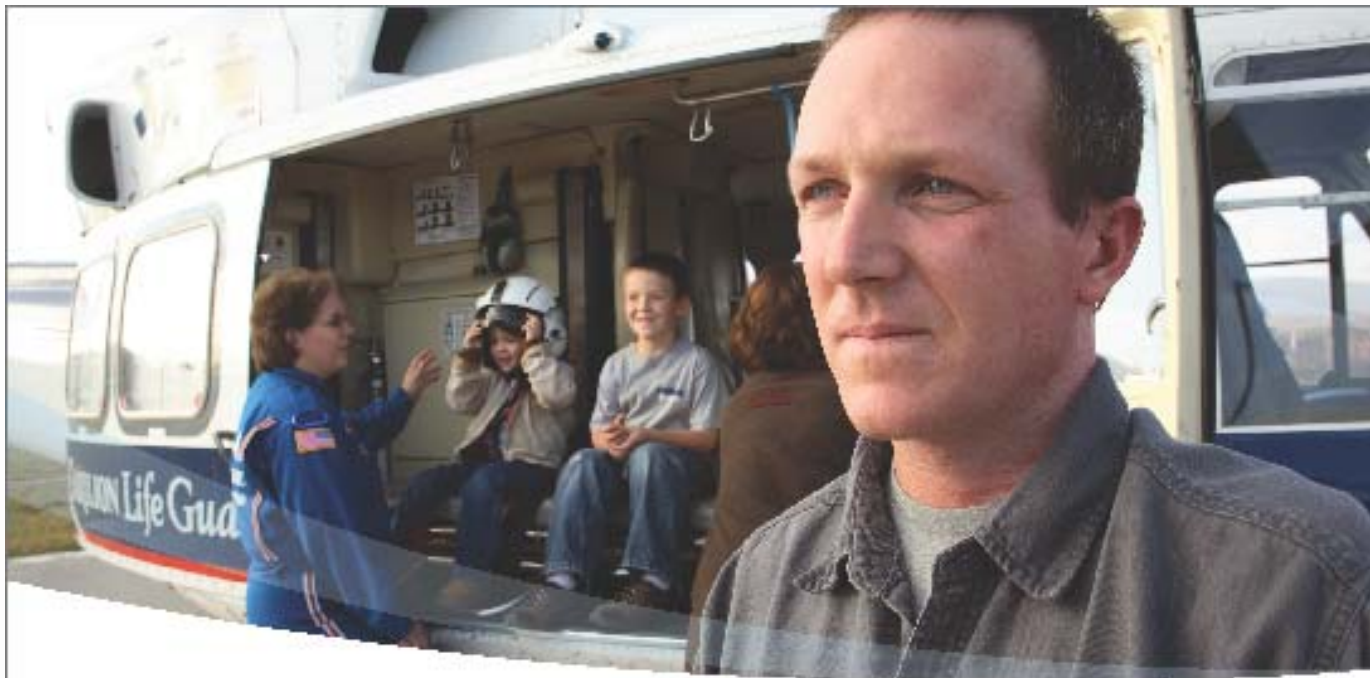
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Phil's Fight



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Case Study



It's my fight.

*Philip Jarvis
Lexington, Virginia*

My life flashed before my eyes when a high voltage power line landed on me at work. Life-Guard 10 came to the rescue and provided emergency treatment when no one else could. Without Carilion's trauma team, I wouldn't be here today. I count on Carilion Clinic for my life.

CountOnCarilion.org



Case Study - Complications

- January 2009 developed a traumatic cataract in left eye. Small cataract in right.
- Cataract in left eye removed.
- Complication associated with surgery – increased risk of retinal detachment especially in traumatic cataracts.
- He has a new computerized prosthesis, adjusts to terrain.
- He is progressing well, he is young and has no previous medical conditions.



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Case Study

- Where is he now.
- He went back to work February 1, 2009
- Supervisor for new service of high speed internet with same power company.
- One day, he hopes to possibly climb again. He has the will and is a survivor.



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Case Study

- Phil prior to accident
- Phil on Sept. 19, 2009, he climbs again!



Case Study

- Phil's Fight
Video



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Welcome

- Surprise



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Case Study

Questions?



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