VANDERBILT UNIVERSITY MEDICAL CENTER

Protocol: Electrical Injury Practice Management Guideline	Category	Clinical Practice
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Table of Contents

I. Objectives

Describe practice management guidelines for the care of patients with electrical injuries presenting to Vanderbilt University Medical Center (VUMC).

II. Population

All patients evaluated and/or admitted at VUMC after sustaining an electrical injury.

III. Definitions

a. Ohm's Law: I=V/R; I=Current, V=Voltage, R=Resistance.
The amount of damage is dictated by the current, which depends on both the voltage and the resistance. Resistance is altered by patient and environmental factors such as protective clothing, wet or dry skin, open wounds, or anatomic pathway of the current. Voltage, which is static at the source, is used as a surrogate for degree of injury.

b. Alternating current is when electricity in a line cycle, or reverses polarity, many times per second. This is the case for much of the electricity delivered in North America, with few industrial and commercial exceptions. This also obviates discussion of so-called "entry" or "exit" sites as every contact point is effectively both.

c. High voltage electrical injury is that sustained at a source of ≥1000 Volts; this is arbitrary, but widely used in clinical and research settings. Household voltage is 120V AC in the United States and are, by definition, low voltage electrical injuries

d. Arcing is the process by which rogue current passes through the air and may cause thermal burns similar to flash burns. These arcs may reach up to 4000˚C and do not constitute an electrical injury.

e. Electrocution means death by electricity. Not all electrical injuries constitute electrocutions.

IV. Principles

a. Electrical injuries are different than classical thermal burns. The flow of electrical current through the body causes extensive tissue damage and generates heat, which further damages affected tissues. The visible cutaneous injury, as defined by the TBSA primarily at the contact points, insufficiently estimates the true size of the tissue destruction and the volume of resuscitation required. and the co-efficient used for calculation of initial resuscitations rates is larger.

b. Associated Injuries

i. Cardiac Injuries - dysrhythmia, myocardial ischemia, decreased ejection fraction, etc.; may occur with low or high voltage injuries

ii. Traumatic Injuries – tetanic contractions may be so forceful that they cause muscle tension sufficient to cause spinal or other orthopedic fractures; contractions may also violently push patients and cause secondary trauma through falls

iii. Ocular Injuries – cataracts following electrical injury has been

iv. Muscular Injuries – direct tissue destruction from current and heat may cause muscle necrosis and compartment syndrome, requiring

fasciotomy; severity of injury is inversely proportional to cross-section of the affected body area, so hands, feet, and distal extremities are at particularly high risk of compartment syndrome

v. Rhabdomyolisis – muscle injury and death, with or without compartment syndrome, may cause myoglobinuria, leading to rhabdomyolisis and acute kidney injury; this would necessitate further escalation in resuscitation

c. Perception of severity depends on effective current
    i. Below 1 mA – not perceptible
    ii. 1 mA – barely perceptible
    iii. 5 mA – slight shock; involuntary actions seen
    iv. 6-49 mA – painful shock; loss of muscle control; "let-go" range
    v. 50-99 mA – extreme pain, respiratory arrest, severe contractions; cannot voluntarily let go; death possible
    vi. 100-4300 mA – ventricular fibrillation range; nerve and muscle damage; death likely
    vii. 10,000 mA – cardiac arrest; internal organ damage; death probable
d. Body resistance is mostly at the skin. Current (and thus injury severity) is altered at static voltage due to factors that either raise resistance (protective clothing, dry conditions) or lower resistance (wet skin, open wounds, etc.).
e. Beyond current and resistance, the pathway of the current and the length of time in contact with the circuit may strongly affect the severity of electrical injury. The effective current becomes additive over time, such that 100mA for 3 seconds is equivalent to 900mA for 0.3 seconds, either of which could lead to ventricular fibrillation.
f. Low Voltage injuries – while perceived as less harmful, can become deadly under certain conditions, such as prolonged contact or decreased skin resistance. Less than 100 milliamperes (mA) separates imperceptible shocks (1mA) from potentially deadly fibrillation (100mA). Even household voltage (120V) can cause fibrillation with the lowered resistance of wet skin. Similarly
g. Tissue destruction from high voltage electrical injury is progressive and may continue beyond acute resuscitation and potentially beyond initial hospitalization. Depth and TBSA may both drastically change in that time.

V. Assessment

Initial assessment of the patient with an electrical injury does not differ from the typical assessment of a combined burn-trauma patient. Concomitant blunt trauma should be assumed until disproven (cervical collar, spine precautions, etc.)

a. Patients presenting in cardiac arrest should be treated as both a cardiac patient and a trauma patient. ACLS protocols should be instituted whilealso considering reversible causes of traumatic arrest including hemorrhagic shock and pneumothorax.
b. Fluid resuscitation (balanced crystalloid solution) during the primary survey:
    i. Adult patients should be started at 500ml/hr.
    ii. 6–13 year-old patients should be started at 250ml/hr.
    iii. Children under 6 should be started at 125ml/hr.
c. Designation of high versus low voltage injury during secondary survey
d. During the secondary survey burn size should be calculated and the fluidrate should be adjusted using the formula:
e. Complete neurovascular exams of each extremity should be done and documented at time of admission.

VI. Diagnosis

Patients presenting with a history of an electrical injury should be treated as ahigh-voltage injury until the actual voltage is identified. Line workers and electricians often know the voltage they were exposed to, but if the patient does not know or cannot say, a call to the local electrical company can quickly identify the voltage of the electrical line associated with the injury.

Note: With the exception of cardiac dysrhythmias, the remainder of these diagnostic and therapeutic recommendations are for high voltage injuries only and should not be undertaken for low voltage injuries

a. Cutaneous burns are diagnosed as in any other mechanism, they should be quantified by both size (% TBSA) and depth.
b. Traumatic injuries: A traumagram should be done on all patients with a high-voltage injury. If injuries are identified and the trauma team was notinvolved at time of evaluation, they will be consulted.
c. Compartment syndrome: Classic signs and symptoms of compartment syndrome (5Ps: Pain Pallor, Paresthesia, Pulselessness, Paralysis) are unreliable in the setting of electrical injuries, due to distracting injuries and paresthesias from nerve injury. Clinical evaluation is the paramount for diagnosis of compartment syndrome: tight compartments to palpation, pain with flexion/extension, or fixed flexion. Pulselessness and paralysis are late signs of compartment syndrome and diagnosis should come before those signs.
d. Rhabdomyolysis is diagnosed based on presence of myoglobinuria, elevated CK, and/or elevated serum potassium, and needs to be evaluatedon admission and followed to identify resolution or improvement.

VII. Interventions

a. Recommended labs:

i. Standard burn admission labs (CBC, BMP)
ii. Creatine Kinase (CK)
iii. BMP q6hr to evaluate potassium and Creatinine trends in patientswith high voltage electrical injuries.
iv. UA to evaluate for myoglobinuria
v. Not Troponin or CK-MB – no known correlation to pathology in this population.

b. Tests:

i. EKG. Cardiac arrhythmias are commonly noted after electrical injury, they are more common after high-voltage injury than low-voltage. *Appropriate for low voltage injuries as well.*
ii. Q1hr neurovascular checks with elevation for extremities with contact points that do not require immediate fasciotomy
iii. Traumagram for all patients with a high-voltage mechanism

c. Consults:

i. Ophthalmology – on admission to obtain a baseline examination and prior to discharge. Electrical cataracts can occur in 5-8% of electrical injury patients. It typically takes months to develop but has been described more acutely. This is especially true in workplace injuries as subsequent onset of cataracts would still be covered under workman's compensation if proven to not be present initially.

VIII. Treatments

a. Resuscitation

i. Rule of 10's and adjusted ideal body weight (AIBW) will dictate fluid start rate:
- Add 20% to TBSA then use above "Rule of 10s" calculation
- < 80kg: 10 x _____ (%TBSA) = _____ mL/hr
- ≥ 80kg: Additional 10mL for every 1kg over 80kg)

ii. Urine output goals depend on the presence of myoglobinuria. If there is any ambiguity, keep UOP goal at 1-2mL/kg/hr until diagnosis is certain. In the absence of myoglobinuria, UOP goal will be based on AIBW ranges
iii. *Please see Acute Burn Resuscitation PMG for details*

b. Monitoring

i. All patients with a high-voltage mechanism require cardiac monitoring for 24 hrs. post-injury
ii. All patients with chest pain, an abnormal EKG, or a loss of consciousness require cardiac monitoring for 24 hrs. post-injury

c. Medications

i. Multimodal pain control per burn center practice including Gabapentin, PRN Oxycodone, and scheduled Tylenol. Avoid NSAIDs in these patients given the risk of AKI and need for operative intervention.
ii. Until resuscitated, patients with electrical injury induced

rhabdomyolysis should not receive acute diuresis. Initiation of diuresis must be driven by the burn attending.

d. Operative Interventions
   i. Fasciotomy is indicated emergently for patients with compartment syndrome. Escharotomies may also be necessary, though high voltage electrical injuries frequently cause widespread tissue damage without the cutaneous manifestations seen in thermal burns, thus relatively sparing overlying skin.
   ii. Excision of full thickness cutaneous burn is indicated per usual practice. Grafting at the index operation is strongly discouraged as progressive tissue destruction due to microvascular destruction is quite common in high voltage electrical injuries and virtually guarantees graft loss.
   iii. Amputations: Patients with high-voltage electrical injuries have higher rates of amputation compared to other burn injury mechanisms. If amputation is determined to be necessary by theburn surgery attending, a second opinion from either a burn, ortho,or plastic surgeons will be considered prior to proceeding with amputation.

IX. Disposition

a) The following patients should be admitted to the BICU:
   i. Patients with high-voltage electrical injury mechanism
   ii. Any patient with additional critical care needs
   iii. Any patient acute requiring resuscitation (cutaneous burns, risk of rhabdomyolysis)
   iv. Any patient requiring cardiac monitoring and has other critical care needs
   v. Any patient requiring q1hr neurovascular checks

b) The following patients should be admitted to the burn stepdown unit:
   i. Low-voltage electrical injuries requiring admission for woundcare, pain control, or therapy evaluation and treatment.
   ii. Any patient requiring cardiac monitoring without any critical care needs

c) The following patients can be discharged from the ED:
   i. Low-voltage injury mechanism without EKG changes, without history of loss of consciousness, and not meeting and other admission criteria

X. Other considerations

a. Other long-tern sequelae: Varied and non-specific neuropsychiatric sequalae have been described. Without intentional screening for these issues, they can be easily missed.

i. Psychological: A social work (SW) consult is mandatory on these patients. SW will perform their standard screening and make recommendations for a formal psychiatry consult as needed.

ii. Neurological, Central: Cognitive deficits may be missed during the index hospital stay. Cognitive evaluations are required for these patients prior to discharge. If a deficit is noted, appropriate follow-up should be scheduled.

iii. Neurological, Peripheral: A complete neurological exam should be performed and documented at time of admission and prior to discharge.

XI. References

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