BMJ Best Practice

Electrical injury

Straight to the point of care

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Summary

Electrical injury may be caused by exposure to high- or low-voltage electricity or lightning. Electronic control devices (e.g., Tasers) may also cause a mild electrical injury.

Recognition of arrhythmias is an essential element of the initial evaluation of electrical injury.

Most electrical shocks cause no injury.

May cause electrical and thermal burns, and secondary injuries due to a fall, or severe tetany. Pressure wave injury may occur subsequent to electrical blast.

Survivors of high-voltage electrical injury or lightning strikes can suffer long-term sequelae, and regular follow-up is essential.

Definition

Electrical injuries may be caused by exposure to natural lightning or electricity in the home or workplace. Electrical injury includes electrocution, electric shock, burns, and secondary injuries.

Epidemiology

Between 2020 and 2021, there were 5003 accident and emergency department attendances due to electric shock in the English National Health Service.[3]

Children aged younger than 6 years are more likely to be injured in a home-related electrical incident than older children.[4] [5] Men are injured more than women, probably due to the preponderance of male workers in construction-related industries.

Regional data provide an insight into the global prevalence of electrical injury. In the Calgary Health Region of Canada, 10 cases of severe electrical injury were reported between 1996 and 2002, resulting in an annual incidence of 2.4 per 1 million population.[6] All patients were male; 6 died due to severe electrical trauma, giving rise to a death rate of 1.4 per 1 million population.[6] In Diyarbakir, Türkiye, 126 deaths due to electrocution were reported between 1996 and 2002. Males (69.9%) were more commonly affected than females.[7] In a burn centre in Enugu, Nigeria, 24 people presented with severe electrical injuries between 1995 and 2004, with a male to female ratio of 4.8:1.[8] In Tabriz, Iran, a study of people presenting with severe electrical burns over a 5-year period found that 98% of the 202 people admitted were male.[9] In Shiraz, Iran, 95.3% of people with severe electrical injury were male.[10] The male predominance in all studies highlights the need for effective prevention strategies in occupational-related injuries.

In 2021, there were 152 fatal occupational exposures to electricity in the US and 2380 cases of non-fatal occupational electrical injuries and illnesses involving days away from work.[11] [12]

In the US, there are approximately 28 deaths attributed to lightning a year.[13]

Aetiology

Electrical injuries can occur at home, in the workplace, or outdoors as a result of lightning. Electrical injuries are arbitrarily divided into high voltage of 1000 V or more and low voltage of less than 1000 V.

Home electricity is usually alternating current (AC). In the US, Canada, and the Caribbean, home voltage is typically 110 V at 60 Hz, with 220 V used for high-power appliances. In Europe and Australia, household voltage is typically 220 V to 240 V at 50 Hz.

Direct current (DC) is a constant current and commonly used in industrial settings. In industry, higher voltage sources are common. As a consequence, workers may be exposed to voltages hundreds of times higher than found in the typical home.

Lightning is present in all thunderstorms. The National Weather Service (US) estimates that 100,000 thunderstorms occur in the US each year. Cloud-to-ground lightning occurs approximately 30 million times each year. Lightning can produce 10 million volts or more of DC, although exposure time is generally brief.

The use of electronic control devices has increased worldwide in recent years. These devices deliver a temporary high-voltage, low-current electrical discharge to override natural muscle-triggering mechanisms. A single exposure of an electronic control device on healthy individuals can be assumed to be generally safe, but can have deleterious effects when used in the field, in particular if persons receive multiple exposures, are intoxicated, show signs of 'excited delirium', or present with medical comorbidities.[14]

There are anecdotal reports of people being electrocuted by smartphones, but there do not appear to be any substantiated claims. Smartphones work on 5 volts, so electrocution is unlikely. Nevertheless, the charging cable that is plugged into the wall presents the same dangers as any electrical home appliance. Reports of burns caused by e-cigarettes appear to be related to overheating of batteries, rather than an electrical injury.[15]

Pathophysiology

The physical laws governing electricity are important for an understanding of the pathophysiology of electrical injuries.

Transfer of electrical energy into the body is a complex phenomenon that is extremely variable and situation-dependent, but will follow certain natural laws. Accidental exposure to electricity can produce no injuries or be instantly fatal.

Electricity flows in circuits that contain voltage, current, and resistance. For practical purposes, there must be a complete circuit for electricity to flow. The circuit may be completed back to the electrical source itself or by contact with a ground, a phenomenon called 'earthing'. Any surface that has a lower electrical potential than the source voltage will act as a ground and complete the circuit.

Ohm's law states that current, voltage, and resistance exist in a proportional relationship, V = IR (V = voltage, I = current, R = resistance). The tissues of the body are in effect the resistance that determines the current that will flow through the body. Higher resistance leads to lower current flow; for a current to pass through the body, the resistance in the human body needs to be less than the surroundings. Tissue resistance will vary, with dry thick skin presenting the greatest resistance and moist broken skin or mucous membranes representing the least. For example, a dry finger would have 40,000-1,000,000 ohms of resistance, whereas a wet finger would have a lower resistance of 4000. The voltage drop across this resistance will generate heat, so high-resistance tissues will be more likely to suffer a thermal burn whereas areas of lower resistance, such as nerves and blood vessels, would allow flow through the body affecting internal organs, especially the heart.

Electricity adversely affects the cardiac conduction system causing arrhythmias, and can cause direct myocardial damage. High voltage or DC current usually causes asystole, and AC current usually causes ventricular fibrillation (VF).

If, for example, a worker comes into contact with a voltage source and completes a circuit through both hands, current will flow through the heart. This situation is potentially more dangerous and arrhythmogenic than if the circuit completes through the right hand and foot, where the heart will be spared.

The respiratory drive may arrest due to paralysis or tetanic contractions of the respiratory muscles. Skin and deep burns, neurological sequelae, and electrical vascular injury are also common.[16]

Lightning delivers a very high voltage direct current of short duration. Thus, the actual amount of energy may be less than with other exposure. As a consequence, victims of lightning exposure rarely sustain extensive tissue destruction or large cutaneous burns, but have significant damage to the conduction system of the heart.

DC causes a single muscle contraction, whereas AC causes tetanic muscle contraction. AC shock of the hands may cause tetanic contractions that prevent the person from letting go, increasing the energy delivered to the body.

Classification

Types of electrical injury[1]

1. Electrocution (fatal)
2. Electric shock
3. Burns
4. Electronic control devices (e.g., Taser)
5. Falls caused by contact with electric energy.

Mechanism of electrical injury[1]

1. Electric shock
    - Direct contact with electrical energy.
2. Electric arc burn
    - Flow of electrons through a gas (such as air) to a victim at ground potential (supplying an alternative path to air).
    - Heat generated by an electrical arc can also cause flash burns.
3. Electric contact burn injury
    - May be internal or external.
    - Thermal injuries (flash or flame burns) - current does not flow through the body and injuries are usually confined to the skin.
    - High voltage burns may have significant underlying injury with inconspicuous entry and exit wounds.

Types of electrical injury[2]

1. Low voltage
    - Less than 1000 volts
    - Usually occurs in the home.
2. High voltage
    - Greater than 1000 volts
    - Usually occurs at work.

Typical injuries[2]

1. Skin

Note: all types of electrical injury may result in partial- to full-thickness wounds, and can affect subcutaneous tissues.

- Electrothermal burns - entrance and exit wounds

- Arc burn
- Flame burns
- Lightning injuries - Lichtenberg figures (fern-like pattern on skin) are pathognomonic.

2. Respiratory

- Respiratory arrest as a consequence of central nervous system inhibition, prolonged paralysis of respiratory muscles, tetanic contraction of respiratory muscles, or as part of cardiorespiratory arrest.

3. Cardiovascular

- Arrhythmias - VF common in low-voltage AC current shock; asystole common in high-voltage shock (AC or DC)
- Conduction abnormality - sinus bradycardia and high-degree AV block
- Myocardial damage - direct injury or ischaemia from coronary artery spasm or hypotension.

4. Musculoskeletal

- Bone - severe electrothermal injuries (e.g., periosteal burns, destruction of bone matrix, osteonecrosis); fractures and dislocation due to falls and forceful tetany
- Muscle - oedema and tissue necrosis resulting in compartment syndrome and rhabdomyolysis.

5. Neurological

- Common manifestations - loss of consciousness, generalised weakness, autonomic dysfunction, respiratory depression and memory problems
- Keraunoparalysis (lightning paralysis) - reversible, transient paralysis; associated sensory disturbances and peripheral vasoconstriction
- Hypoxic encephalopathy, intracerebral haemorrhage, and cerebral infarction
- Sensorineural hearing loss and hypoacusis due to ruptured eardrums.

Case history

Case history #1

A 25-year-old man was working on an electrical outlet in his house. His wife heard a loud crackling sound and upon entering the room her husband was working in, found him slumped on the floor. She turned off the electricity. Her husband was unresponsive and did not have a pulse.

Case history #2

A 66-year-old male golfer was found on a fairway during a thunderstorm. His clothing appeared scorched and he was unresponsive with an absent pulse and no respirations.

Other presentations

Most cases of electrical injury have no significant sequelae; however, they may present with multiple trauma, and, unless witnessed, the electrical injury that caused the trauma may not be readily apparent. Information from witnesses concerning the injury can be critical, especially if the patient is unconscious.

Approach

People may present immediately after the injury or late with cardiac or neurological complications.

People with electrical injury should be evaluated as a multiple trauma patient. Airway, breathing, and circulation assessment, and spine immobilisation, should be performed as part of a primary survey. Prior to determining the person's cardiorespiratory status, the rescuer must first ensure that the danger of further shock has been removed to allow for a safe environment for assessment.[20]

History

In the case of an immediate injury, the history surrounding the event is critical. It is important to determine if the patient lost consciousness at any time.

If the patient is alert, a complete description of the event should be obtained. This should include:

- The nature of electrical contact
- High or low voltage, or lightning
- Length of contact
- Time since injury.

If the patient is unconscious, this information is obtained from emergency medical service (EMS) personnel or witnesses. The possibility of associated injury should be determined by asking where the patient was found or if they were working off the ground.

Examination

In some cases the physical examination might be entirely normal. Hypothermia should be suspected when the exact time of injury is unknown, or if the person might have been immobile on the ground for more than a few minutes. In these cases, measurement of core temperature is important.

The physical examination should include a primary survey for life threatening injuries, followed by a head-to-toe secondary survey. An injured extremity may have minimal or no external signs of electrical injury. The percentage of superficial burns may bear no relation to the underlying tissue damage, and the rule of nine should be used with caution. Deep tissue injury in the extremities can lead to swelling and subsequent compartment syndrome. This should be suspected and treated accordingly without delay. The colon and the small intestine are the most frequently injured visceral organs. The development of abdominal compartment syndrome secondary to an electrical injury can be catastrophic.[21]

Patients may present with an altered mental state. This could be due to a direct effect of electricity on the brain, a result of anoxia from a cardiac arrhythmia, or as a result of secondary trauma.

Keraunoparalysis (lightning paralysis) is a reversible, transient paralysis that is associated with sensory disturbances and peripheral vasoconstriction in lightning victims.[19] [22]

Investigation

In many countries, modern EMSs systems and availability of automated external defibrillators may allow for evaluation and treatment of cardiac dysrhythmias in the pre-hospital setting.

On arrival at hospital, immediate cardiac monitoring is imperative for rhythm analysis and monitoring.

A 12-lead ECG should be performed immediately. Non-specific ST-T changes are common. Atrial fibrillation is the most common arrhythmia.[23]

Full blood count, serum electrolytes, liver function tests, urea, creatinine, creatine kinase, and urinalysis for myoglobin should be performed. In the presence of haemodynamic instability, and where internal injuries are suspected, cross-matching and coagulation studies should be requested. Troponin should be preferred as the most specific cardiac injury marker.

If compartment syndrome is suspected, compartment pressures can be measured in the emergency department. This can be particularly useful for the unconscious person.

A urine toxicology screen for illicit drugs and blood alcohol measurements may be indicated, because concurrent substance use may have contributed to the accident.[24]

Imaging studies

A chest x-ray for evaluation for flash pulmonary oedema secondary to cardiac dysfunction may be useful. Other imaging may be necessary depending on secondary injuries. A computed tomography (CT) head scan should be performed if a head injury is suspected. A magnetic resonance imaging brain scan is recommended after initial evaluation with CT head for a more complete evaluation of head injury and for a prognostic role in anoxia coma.[25]

History and exam

Key diagnostic factors

presence of risk factors (common)

- Risk factors for electrical injury include: male sex; age <6 years; and construction industry work.

loss of consciousness (common)

- Underlying causes include direct effect of electricity on the brain, anoxia due to cardiopulmonary arrest, or head trauma.
- May be multifactorial.

pre-hospital CPR or defibrillation (common)

- Duration of CPR and use of automatic emergency defibrillation should be documented.

tachycardia (common)

- As a result of tachyarrhythmia or response to hypotension.

hypotension (common)

- Blood pressure may be low in response to a specific cardiac arrhythmia.
- Blood loss from internal trauma and severe burns causes hypotension.

low Glasgow Coma Scale score (common)

- Electricity can have direct effects on the central nervous system.
- A patient's mental status can also be altered by trauma and anoxia secondary to respiratory arrest or cardiac arrhythmias.

burns (common)

- Extent and nature of any skin burns should be documented.
- Small area burns might indicate a deeper, more extensive burn.

physical injuries (common)

- Secondary injuries such as fractures, contusions, and head injury may be present.
- The colon and the small intestine are the most frequently injured visceral organs.[21]

Other diagnostic factors

diminished peripheral pulses and poor capillary refill (uncommon)

- May indicate hypovolaemic shock or developing compartment syndrome.

low core body temperature (uncommon)

- Hypothermia should be suspected when the exact time of injury is unknown, or if the patient might have been immobile on the ground for more than a few minutes.

confusion (uncommon)

- Patients may present with an altered mental state. This could be due to a direct effect of electricity on the brain, a result of anoxia from a cardiac arrhythmia, or as a result of secondary trauma.

paralysis (uncommon)

- Keraunoparalysis (lightning paralysis) is a reversible, transient paralysis that is associated with sensory disturbances and peripheral vasoconstriction in lightning victims.[19][22]

Risk factors

Strong

age <6 years

- Younger children are more likely to play with or chew on electrical cords, or insert objects into household electrical outlets.[4] [5]

construction industry workers

- Electricians are at risk for electrical shock. Other construction personnel may come into contact with live electrical wires and are at higher risk for accidental electrocution.[12] For example, house painters may accidentally place an aluminium ladder near electrical wires.

male sex

- The construction industry is a male-dominated industry, placing men at risk for injury.

Weak

participation in outdoor sports

- People participating in outdoor sports may be at higher risk of lightning electrocution.[13]

Investigations

1st test to order

Test	Result
ECG • Should be performed immediately on presentation.	**non-specific ST-T changes; atrial fibrillation; ventricular fibrillation; asystole**
FBC • Ordered as baseline. • Advised if trauma is suspected. • Low haemoglobin suggests internal bleeding.	**normal**
electrolytes • Ordered as baseline. • Abnormalities such as elevated potassium, creatinine, or urea suggest shock or rhabdomyolysis.	**normal**
LFTs • Ordered as baseline.	**normal**
coagulation studies • Ordered as baseline. • Advised if trauma is suspected.	**may be normal or abnormal**
creatine kinase • If elevated 5 times normal, suggests compartment syndrome with rhabdomyolysis.	**normal; or elevated in the presence of muscle lysis or muscle necrosis**
urine myoglobin • Rhabdomyolysis results in the precipitation of myoglobin in the renal tubules and subsequent risk of nephropathy.[26]	**negative; or positive in the presence of muscle cell lysis or muscle necrosis**
cardiac enzymes (CK-MB and troponin) • Need to be interpreted with caution.	**may be elevated**
toxicology screen • Recommended for all patients admitted with multi-trauma. • Alcohol may have contributed to the cause of the injury. • Cocaine use might increase cardiac vulnerability to ventricular fibrillation.[27]	**may be positive for alcohol or cocaine**
chest x-ray • Suggests flash pulmonary oedema secondary to cardiac dysfunction.	**increased alveolar markings**

Other tests to consider

Test	Result
plain x-rays • Usefulness will depend on the index of suspicion of an injury in the affected body part.	**confirm suspected bony injuries**
head CT • Indicated if head injury is suspected.	**intracerebral haemorrhage; skull fracture**
head MRI • CT scanning remains the test of first choice, but MRI can be used later following stabilisation; MRI is the method of choice for evaluating the full extent of brain injury.[25] [28]	**detailed information about brain injury**
compartment pressure measurements • Can be measured if compartment syndrome is suspected. • Differential pressure within 20-30 mmHg of the diastolic pressure (delta pressure) is considered a strong indicator for early surgical intervention.[29] Care should be taken when using this criterion for patients who are receiving vasodilatory medications whose diastolic blood pressure is low. • Patients with an intra-abdominal pressure ≥25 mmHg associated with organ dysfunction or failure should be submitted immediately to surgical decompression.[21]	**variable**

Differentials

Condition	Differentiating signs / symptoms	Differentiating tests
Cardiac arrest	• History of cardiac disease or family history of sudden cardiac death.	• Elevated cardiac enzymes. However, elevated creatine kinase 5 times normal may suggest compartment syndrome with rhabdomyolysis in patient with electrical injury.
Ventricular arrhythmia	• History of cardiac disease, in particular recent cardiac ischaemia.	• ECG - abnormal rhythm.
Illicit drug use	• History of illicit drug use. • Track marks. • Altered mental status.	• Urine toxicology screen for illicit drugs.
Acute stroke	• History of hypertension or vascular disease. • Limb hemiparesis, cranial nerve abnormalities, or speech changes.	• CT brain - haemorrhage or areas of ischaemia.
Subarachnoid haemorrhage	• History of known cerebral aneurysm or risk factors for cerebral aneurysm (e.g., polycystic kidney disease). • Severe headache.	• CT brain - subarachnoid blood. • Lumbar puncture - elevated RBC count with xanthochromia.
Generalised seizures	• History of seizures or risk factors for seizures (e.g., alcohol abuse, intracranial lesion). • Witnessed tonic-clonic movement. • Tongue biting. • Urinary or faecal incontinence.	• EEG - epileptiform discharges.

Criteria

Criteria for admission with electrical injury[23]

1. History of loss of consciousness.

2. ECG abnormalities.

3. Secondary injuries requiring further management (e.g., burns, limb injuries).

Approach

People with electrical injuries require immediate airway, breathing, and circulation assessment. They should be treated as a multi-trauma patient with cervical immobilisation at least until the full extent of their injuries has been quantified.[19] Prior to determining the patient's cardiorespiratory status, the rescuer must first ensure that the danger of further electrical injury has been removed to allow for a safe environment for assessment.[20]

Except for cases of sudden cardiac arrest, lightning strikes generally do not result in immediate injuries that pose a threat to a person's life.[19] This implies that individuals who do not experience cardiac arrest when emergency responders arrive are unlikely to die within the next hour. Therefore, priority should be given to administering resuscitation and medical intervention to those who are presumed to be dead initially.[30]

Most patients will have no sequelae from low-voltage electrical injury in the non-industrial setting and may be discharged following normal ECG and physical examination.

Patients with loss of consciousness, persistent ECG changes, and significant secondary injuries should be admitted to hospital.[23] Standard supportive care is required.[19]

If the person has been injured by an electronic control device (e.g., Taser), treatment is essentially the same as for all electrical injuries. Occasionally, the dart used to deliver the shock, or a fall resulting from the shock, causes additional injury that should be evaluated.[14]

Arrhythmias

People with life-threatening arrhythmias should be treated appropriately with standard ACLS protocols.[31] [32] People who are at high risk, such as those with ECG changes, loss of consciousness, and/or high-voltage injuries, will still be advised to undergo 24-hour monitoring.[33] People with ECG changes should be monitored for a minimum of 6 hours after injury. People with consistent abnormal ECG readings should be admitted for ongoing monitoring.[34]

People with cardiac arrest and secondary anoxic brain injury may be candidates for targeted temperature control.[35] [36] Guidelines recommend that comatose adult patients with return of spontaneous circulation receive targeted temperature control by selecting and maintaining a constant temperature between 32°C and 37.5°C (89.6°F and 99.5°F) for at least 24 hours.[31] [32][37]

Burns

Cutaneous burns should be placed under cool or lukewarm running water when possible, preferably for 20 minutes.[38] Plain or mild soap can be used to cleanse minor burn wounds. Wounds can then be covered with simple, clean dressings, not necessarily sterile. Cling film can be used as a temporary dressing which is cheap, widely available, and allows subsequent re-examination through the dressing. Early discussion with the local burns team is required to decide if emergency surgery or transfer is required.

Purely electrical burns and flame burns derived from the ignition of clothing tend to be deep-dermal to full-thickness, and are likely to require surgical intervention at some stage. Flash burns derived from electric arcs are thermal in nature and usually superficial.

Intravenous fluid should be given, but there are no clear guidelines on the amount, as the 'rule of nines' does not incorporate the underlying tissue damage in electrical injury.[39] Fluid resuscitation is guided by blood pressure, pulse rate, urine output, level of consciousness, and central venous pressure monitoring if appropriate.

Tetanus immunisation history should be checked, with vaccination and tetanus immunoglobulin considered if the person is not immune.[40]

Extremity injury

Fractures and dislocations should be appropriately managed.

The limb should be assessed for compartment syndrome, and early surgical intervention with fasciotomy/escharotomy or amputation of a non-viable extremity performed.[29] [41] See Compartment syndrome of extremities (Management) .

If rhabdomyolysis is present, intravenous fluids should be given at a rate that ensures a urine output of at least 1 mL/kg/hour. Definitive management for cases of severe rhabdomyolysis might require renal replacement therapy.[26]

Neurological injuries

Head and spinal injuries should have appropriate neurological care.

Treatment algorithm overview

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer

Acute		(summary)
all patients		
	1st	basic life support, cervical immobilisation, and transfer to ED
with cardiac arrhythmias	plus	ACLS protocols
with cardiac arrest	plus	consider targeted temperature control
with cutaneous burns	plus	dressing and intravenous fluid
	adjunct	immunisation
with extremity trauma	plus	appropriate management of fractures, dislocations, and compartment syndrome
with rhabdomyolysis	plus	intravenous fluid to maintain urine output >1 mL/kg/hour
with neurological injuries	plus	appropriate management of head and spinal injuries

Treatment algorithm

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer

Acute

all patients

Patient group	Tx line	Treatment
all patients	**1st**	**basic life support, cervical immobilisation, and transfer to ED** » Prior to determining the patient's cardiorespiratory status, the rescuer must first ensure that the danger of further shock has been removed to allow for a safe environment for resuscitation.[20] » Patients with electrical injuries require immediate airway, breathing, and circulation assessment. They should be treated as a multi-trauma patient with cervical immobilisation at least until the full extent of their injuries has been quantified.[19] » Except for cases of sudden cardiac arrest, lightning strikes generally do not result in immediate injuries that pose a threat to a person's life. This implies that patients who do not experience cardiac arrest when emergency responders arrive are unlikely to die within the next hour. Therefore, priority should be given to administering resuscitation and medical intervention to those who are presumed to be dead initially.[30] » Most patients will have no sequelae from low-voltage electrical injury in the non-industrial setting and may be discharged following normal ECG and physical examination. » Patients with loss of consciousness, persistent ECG changes, and significant secondary injuries should be admitted to hospital.[23] Standard supportive care is required.[19]
■ **with cardiac arrhythmias**	**plus**	**ACLS protocols** Treatment recommended for ALL patients in selected patient group » Prior to determining the patient's cardiorespiratory status, the rescuer must first ensure that the danger of further shock has been removed to allow for a safe environment for assessment.[20] » Patients with life-threatening arrhythmias should be treated appropriately with standard ACLS protocols.[31] [32]

Acute

» Patients who are at high risk, such as those with ECG changes, loss of consciousness, and/or high-voltage injuries, will still be advised to undergo 24-hour monitoring.[33]

» Patients with ECG changes should be monitored for a minimum of 6 hours after injury. If the ECG is still abnormal, patients should be admitted for ongoing monitoring.[34]

with cardiac arrest — **plus** — **consider targeted temperature control**

Treatment recommended for ALL patients in selected patient group

» In patients with cardiac arrest and secondary anoxic brain injury, targeted temperature control should be considered.[35] [36]

» Guidelines recommend that comatose adult patients with return of spontaneous circulation receive targeted temperature control by selecting and maintaining a constant temperature between 32°C and 37.5°C (89.6°F and 99.5°F) for at least 24 hours.[31] [32][37]

with cutaneous burns — **plus** — **dressing and intravenous fluid**

Treatment recommended for ALL patients in selected patient group

» Cutaneous burns should be placed under cool or lukewarm running water when possible, preferably for 20 minutes.[38] Plain or mild soap can be used to cleanse minor burn wounds.

» Wounds can then be covered with simple, clean dressings, not necessarily sterile. Cling film can be used as a temporary dressing which is cheap, widely available, and allows subsequent re-examination through the dressing.

» Early discussion with the local burns team is required to decide if emergency surgery or transfer is required.

» Intravenous fluid should be given, but there are no clear guidelines on the amount, as the 'rule of nines' does not incorporate the underlying tissue damage in electrical injury.[39]

» Fluid resuscitation is guided by blood pressure, pulse rate, urine output, level of consciousness, and central venous pressure monitoring if appropriate.

adjunct — **immunisation**

Treatment recommended for SOME patients in selected patient group

Acute

		» Tetanus immunisation history should be checked, with vaccination and tetanus immunoglobulin considered if the patient is not immune.[40]
with extremity trauma	**plus**	**appropriate management of fractures, dislocations, and compartment syndrome** Treatment recommended for ALL patients in selected patient group » Fractures and dislocations should be appropriately managed. » The limb should be assessed for compartment syndrome, and early surgical intervention with fasciotomy/escharotomy or amputation of a non-viable extremity performed.[29] [41] See Compartment syndrome of extremities (Management) .
with rhabdomyolysis	**plus**	**intravenous fluid to maintain urine output >1 mL/kg/hour** Treatment recommended for ALL patients in selected patient group » If rhabdomyolysis is present, intravenous fluids should be given at a rate that ensures a urine output of at least 1 mL/kg/hour. » Use of mannitol and alkalisation of the urine is controversial.[42] High volumes of fluid (up to 10 L/day) are the mainstay of treatment, with the amount of fluid administered depending on the severity.[26] [43] » Definitive management for cases of severe rhabdomyolysis might require renal replacement therapy.[26]
with neurological injuries	**plus**	**appropriate management of head and spinal injuries** Treatment recommended for ALL patients in selected patient group » Head and spinal injuries should have appropriate neurological care.

Primary prevention

Prevention of electrical injuries includes home and work safety programmes, especially for children.[4] [17] Knowledge of electrical hazards and awareness of potential causes for injury are essential for all workers in the construction industry.[1]

If lightning or thunder can be seen or heard, risk of electrocution is present and can last for 30 minutes after the storm has passed. Large enclosed structures are safer than smaller or open buildings. If a storm is in the area, water, high places, unprotected small buildings, open fields, isolated trees, and metal towers should be avoided.[18] Enclosed metal vehicles with the windows rolled up (e.g., school buses) provide good protection.[19]

Patient discussions

Available online resources include:

- Health and Safety Executive (UK) [Health and Safety Executive: electrical injuries] (http://www.hse.gov.uk/electricity/injuries.htm)
- National Institute for Occupational Safety and Health (US) [CDC/NIOSH: electrical safety] (http://www.cdc.gov/niosh/topics/electrical)

Monitoring

Monitoring

People who suffer low-voltage injury and minor injuries may be discharged from the accident and emergency department. No data exists regarding appropriate follow-up intervals and long-term outcomes.

Clinical judgement is important to determine follow-up, as there are no guidelines for routine cardiac, neurological, or psychiatric ongoing care.

Complications

Complications	Timeframe	Likelihood
infection	**short term**	**medium**
A complication of both burns and trauma. Culture of all wounds or body fluids should be performed as indicated or suspected by symptoms before beginning treatment if possible. Empirical antibiotic therapy (based on most probable pathogens) should be given. This should be changed to an appropriate narrow-spectrum antibiotic regimen once a causative pathogen is identified. If severe, sepsis can progress to multi-organ failure and shock, with significant mortality.		
compartment syndrome	**short term**	**medium**
A complication of both burns and trauma. Prompt decompression by fasciotomy is mandatory to prevent muscle ischaemia and rhabdomyolysis.		
rhabdomyolysis	**short term**	**medium**
A complication of both burns and trauma. High volumes of fluid (up to 10 L/day) are the mainstay of treatment, with the amount of fluid administered depending on the severity.[26] [43]		
stress-induced ulcers	**short term**	**medium**
A complication of both burns and trauma. Potential benefits of routine prophylaxis against stress ulcers have not been definitively demonstrated, although it is commonly done.[47] [48] [49]		
persistent cardiac conduction disorders	**long term**	**low**
Sinoatrial and atrioventricular nodes are vulnerable to electrical current injury.[2]		
neurological disorders	**long term**	**low**
Memory deficit, peripheral nerve damage, and delayed spinal cord syndromes may occur.[19][44] Anoxic encephalopathy may occur following prolonged respiratory arrest requiring CPR.[2]		
cataracts	**long term**	**low**
Result from electrical injury affecting the head.[19]		
psychiatric sequelae	**variable**	**medium**
Depression, anxiety, PTSD, and somatoform disorders have been reported.[50]		

Prognosis

Mortality is highest in lightning strikes (17.6%) compared with high voltage (5.3%) and low voltage electrical injuries (2.8%).[44] Fatal arrhythmias usually occur immediately. The presence of anoxic encephalopathy determines long-term neurological sequelae. The extent of secondary injuries, especially burns, affects prognosis.[2] One study found that 24 months post-injury, patients with electrical burns had significantly lower Physical Health Composite Scale scores compared with patients with burns caused by fire/flame.[45]

A normal ECG seems to predict absence of late arrhythmias.[46]

Long-term follow-up is important. Delayed neurological and psychiatric complications may occur, particularly after high voltage injuries in which conduction has passed through the central nervous system.[19][44]

Because most people injured by electricity are young and healthy, they tend to do well.[2]

Treatment guidelines

Europe

European Resuscitation Council guidelines 2021 (https://cprguidelines.eu)

Published by: European Resuscitation Council **Last published:** 2021

North America

2023 focused update on adult advanced cardiovascular life support: an update to the American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care (https://professional.heart.org/en/guidelines-and-statements)

Published by: American Heart Association **Last published:** 2023

2020 guidelines for cardiopulmonary resuscitation and emergency cardiovascular care (https://eccguidelines.heart.org/circulation/cpr-ecc-guidelines)

Published by: American Heart Association **Last published:** 2020

Practice guidelines for the prevention and treatment of lightning injuries (https://www.wemjournal.org/article/S1080-6032(14)00274-9/fulltext)

Published by: Wilderness Medical Society **Last published:** 2014

Cardiopulmonary resuscitation and emergency cardiovascular care: part 10.9: electric shock and lightning strikes (https://www.ahajournals.org/doi/full/10.1161/CIRCULATIONAHA.105.166571)

Published by: American Heart Association **Last published:** 2005

Oceania

Rural adult emergency clinical guidelines, (4.1 ed) (http://www.health.nsw.gov.au/policies/Pages/default.aspx)

Published by: Ministry of Health, New South Wales (Australia) **Last published:** 2022

Online resources

1. Health and Safety Executive: electrical injuries (http://www.hse.gov.uk/electricity/injuries.htm) *(external link)*
2. CDC/NIOSH: electrical safety (http://www.cdc.gov/niosh/topics/electrical) *(external link)*

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Key articles

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This approach is in line with the guidance of the International Bureau of Weights and Measures Service.

Figure 1 – BMJ Best Practice Numeral Style

5-digit numerals: 10,000

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numerals < 1: 0.25

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