IRISH ASSOCIATION FOR EMERGENCY MEDICINE

IAEM Clinical Guideline

Management of Thermal, Chemical and Electrical Burns in the Emergency Department

Version 1.0

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ST JAMES'S HOSPITAL

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IAEM recognises that patients, their situations, Emergency Departments and staff all vary. These guidelines cannot cover all clinical scenarios. The ultimate responsibility for the interpretation and application of these guidelines, the use of current information and a patient's overall care and wellbeing resides with the treating clinician.

Revision History

Date	Version	Section	Summary of changes	Author
August 2023	V1.0	All	Final version	JD/DP/AD/OS/ PO'D/AMcC

CONTENTS

GLOSSARY OF TERMS

ABG	Arterial Blood Gas
AC	Alternating Current
CN	Cyanide
CO	Carbon Monoxide
COHb	Carboxyhaemoglobin
DC	Direct Current
ECG	Electrocardiogram
ED	Emergency Department
FiO_2	Fraction of Inspired Oxygen
GCS	Glasgow Coma Scale
Hb	Haemoglobin
HCN	Hydrogen Cyanide
HF	Hydrofluoric Acid
IO	Intraosseous
IV	Intravenous
MetHb	Methaemoglobin
NAI	Non-accidental Injury
O_2	Oxygen
PPE	Personal Protective Equipment
pO_2	Partial Pressure of Oxygen
POCUS	Point of Care Ultrasound
TBSA	Total Body Surface Area
VF	Ventricular Fibrillation

Management of Thermal, Chemical and Electrical Burns in the Emergency Department

INTRODUCTION

Burn injuries are common and can result in both local effects on the microvasculature, as well as a systemic response due to chemical inflammatory mediators. It is imperative that serious complications, including airway compromise, impaired ventilation and significant fluid losses, are quickly recognised and managed. Thus, clinicians should follow an ABCD approach to resuscitation. It is also worth noting that fluid replacement and burn surface area are often over-estimated by clinicians.

There are three major types of burns: thermal, electrical and chemical.

PARAMETERS

Target audience	This guideline is intended for clinical staff working in the ED involved in the management of patients presenting with burns.
Patient population	Adult patients (≥16 years old) presenting with a burn.
Exclusion criteria	Patients <16 years of age.

AIM

The aim of this document is to provide an evidence-based guideline to clinical staff for the management of patients presenting to the ED with burns.

CLINICAL ASSESSMENT

History

- Document:
    - Time of burn
    - Site and size of burn (use Lund & Browder chart)
    - Any other associated injury
- Mechanism of injury
    - Scald: estimated temperature, nature of the liquid, duration of exposure
    - Contact: estimated temperature, nature of surface, duration of exposure
    - Flame / explosion
        - Product that burned / exploded
        - Location (enclosed versus open space)
        - Duration of exposure
        - Inhalation injury
    - Electrical
        - Voltage
        - Type of current (AC or DC)
        - Duration of contact
    - Chemical: type of product
    - Cold
        - Direct contact with cold surface or exposure (frostbite)
    - Radiant sunburn

- First aid
    - Document what aid was given
        - Time started (and how long it was maintained for)
        - Agents used
    - Decontamination method (for chemical exposure)
- Consider NAI in vulnerable adults
- Tetanus status

Cool the burn with cool running water for 20 minutes as soon as possible after the injury. This is useful for up to four hours after the burn. Keep the patient warm.

After the burn has been cooled, cover it with cling film or a clean plastic bag. This helps prevent infection by keeping the area clean. Cling film or plastic won't stick to the burn and will reduce pain by keeping air from the skin's surface.

Do not cover facial burns with cling film. Ensure that cling film is not administered circumferentially to a burn.

EXAMINATION

Airway assessment and management is the first priority. All patients require a primary and secondary survey. Identify any immediate life threats; do not get distracted by the burn injury.

Airway maintenance with cervical spine control

- The cervical spine should be immobilised if there is associated trauma.
- Always examine the nares and oropharynx if there is any possibility of airway involvement.
    - Soot, singed nasal hairs, or singed eyebrows are red flags for possible airway injury (Table 1).
- Any patient who has **any signs of airway burn / inhalational injury** should be referred to the most senior Emergency Medicine doctor on duty / Anaesthetist on call for airway assessment and consideration of early intubation.

Signs of airway burn / inhalational injury	• **Stridor** • **Hoarseness** • Black sputum • Respiratory distress • Singed nasal hairs or facial swelling • Singed eyebrows
Sign of oropharyngeal / tongue burn	• Soot in mouth • Clinical evidence of burn on the tongue • Oedema / erythema on oropharyngeal inspection
Significant neck burn	• Particularly any circumferential burn

Table 1: Red flags for airway burn / inhalational injury (British Burn Association, 2018)

Breathing and ventilation

- Expose the chest and inspect for adequate chest expansion and for injury / burns to the thoracic area, particularly any circumferential burns that could restrict respiration.
- High index of suspicion for lung injury in blast injuries, particularly if occurred in a closed space; there may not always be signs visible on physical examination.
- Monitor respiratory rate and O_2 saturation.
    - Note: peripheral O_2 saturation is inaccurate in carbon monoxide poisoning.
- Chest X-ray +/- POCUS
    - Pneumothorax – increased risk with electrical injury or blast / explosion (Note: blast injuries can result in barotrauma to the lungs without significant obvious external signs of airway injury, thus clinicians should maintain a high index of suspicion)
- Blood gas should be sent on all patients. Check in particular for
    - Carboxyhaemoglobin
    - Methaemoglobin
    - Lactate (see cyanide poisoning below)
    - Consider doing an ABG if the O_2 saturation levels are low to check the pO_2.

Full thickness and/or circumferential thoracic burns may require escharotomy to permit chest expansion. Urgent discussion with burns unit / plastics registrar on-call is indicated.

Circulation

- Monitor heart rate, blood pressure and capillary refill time.
- Obtain ECG (particularly important in electrical burns).
- IV / IO access
    - Take full blood count / renal function / group and hold.
- Burns **≥15% TBSA in adults (≥10% TBSA in children)** can cause profound circulatory shock that can occur from both large fluid losses through tissue damage and from a systemic inflammatory response.
- IV fluid resuscitation as required. Commence fluids as per the Parkland Formula.
    - Fluid boluses may be required to stabilise the patient prior to commencing slower fluid deficit correction as per Parkland formula.
    - **Commence Parkland fluids from time of injury**, not time of arrival in hospital.
    - Get an accurate weight for the patient. (A hoist with a weighing scale can be used for intubated patients).
- Urine output should be maintained at a rate in adults of ≥0.5ml/kg/hr.
    - Consider urinary catheter insertion.

If circumferential burns, check peripheral perfusion – may require urgent escharotomy. Urgent discussion with burns unit / plastics registar on-call is indicated.

Disability

- Assess GCS
- Be alert for restlessness and decreased level of consciousness, which may be due to:
    - Hypoxaemia
    - CO intoxication
    - CN poisoning
    - Methaemoglobinaemia
    - Alcohol and drugs
        - Consider urine toxicology screen

Exposure, environmental control and estimate burn size

Assess temperature (and continue to monitor) and keep patient warm / avoid hypothermia. Consider use of a Bair Hugger.

- Remove all clothing and jewelry when the patient is sufficiently warm.
    - If adherent to skin cut around, do not forcefully remove.
- Don't forget to assess posterior aspect for burns (log roll patient).
- Circumferential burns to limbs and burns with significant tissue oedema can lead to compartment syndrome and may require urgent escharotomy.
- Don't forget other injuries potentially sustained during associated trauma (for example, long bone fractures).
- Be vigilant about the potential for compartment syndrome, particularly with deep limb burns, circumferential burns or associated blunt trauma (for example, fractures).
    - Pain out of proportion to the injury or paresthesia are often early signs.

Glucose

- Check the blood glucose!

Assessment of burn depth

For a burn, epidermal loss needs to have occurred. Typically, there is no epidermal loss in sunburn.

For all burns:

- Document time and date of when the burn occurred.
- Be aware that burns are dynamic.
    - Estimation of the true depth and extent may not be accurate in the first 48-72 hours.
    - All burns should be reassessed after 2-3 days as per local practice and resources (e.g. with primary care (GP) or via a wound care clinic for minor burns or local plastics trauma clinic as discussed with a plastics registrar on-call). Please refer to Table 2.
- Please refer to Appendix 3 for assessment/recognising of burn depth.

Depth	Colour	Blisters	Capillary refill time	Healing	Scarring
Epidermal	Red	No	Brisk 1-2 seconds	Within 7 days	None
Superficial dermal	Pale pink	Present	Brisk 1-2 seconds	Within 14 days	None / Slight colour mismatch
Mid dermal	Dark pink	Present	Sluggish >2 seconds	2-3 weeks. Grafting may be required	Yes (if healing > 3 weeks)
Deep dermal	Present	+/-	Absent	Grafting may be required	Yes
Full thickness	White / brown / black (charred) / deep red	No	Absent	Grafting may be required	Yes

Table 2: The Agency for Clinical Innovation (ACI) Recognising burn depths chart (2018)

Assessment of total body surface area

- Do NOT include area with epidermal burn (erythema only)
- Use Lund & Browder Chart

Secondary survey

The IAEM Traumadoc is a suggested tool to document a secondary survey to identify any other injuries.

Ophthalmological examination

Burns to the eye can occur after heat-related or chemical-related injuries and can result in serious complications, including sight-threatening injuries.

An ophthalmological examination should be conducted with documentation of:

- Visual acuity
- Examination with fluorescein to identify corneal abrasions

It is imperative that the first clinician who sees the patient documents the ophthalmological findings as it may become challenging to perform this examination later on.

MANAGEMENT

1. General
    - Keep the patient warm and avoid prolonged exposure.
    - Avoid intramuscular injections where possible.

2. Pain management
    - Ensure the patient has adequate analgesia – document pain score and reassess post administration of appropriate analgesia.

3. General burn management
    - Cool burn with cool water for 20 minutes if not already done. Consider a shower if available.
        - Note: there is no benefit to cooling beyond 4 hours following exposure.
    - Keep patient warm and take care not to induce hypothermia, particularly if burn area is large.
    - De-roof blisters (Appendix 4) and clear loose skin.
    - Clean burn wound and surrounding surface with saline or sterile water.
    - Reassess burn if required.
    - Apply non-adherent dressing (Appendix 5).
        - For example: cling film with blanket overlying.
    - Elevate limb burns where possible to reduce swelling.
    - Swab any open / contaminated wounds.

4. Onward disposition
    - Epidermal wounds can be discharged home.
    - Minor wounds can be followed up in wound care clinic or primary care (GP) as per local practice and available resources.

- Consider co-morbidities such as cardiac; respiratory; diabetes mellitus or immunosuppression.
- Consider commencing feeding via enteral route.
- Any patient with acute ophthalmological findings should be discussed with the local ophthalmological service.

Refer to Appendix 6 for St James's Hospital Transfer Check List as a sample transfer check list and Appendix 7 for SJH Initial Management of Severe Burns Burns >15% TBSA in adults.

Indications for urgent consultation with Plastics registrar on call in local burns centre:

- ≥ 5% TBSA or any full thickness burn
- Burns site involving face, hands, perineum or feet
- Burn site involving any flexure, particularly neck or axilla
- Circumferential burns to the limbs, chest, abdomen or neck
- Burns with associated inhalation injury
- Electrical injury
- Chemical injury
- Exposure to ionising radiation injury
- High pressure steam injury
- All hydrofluoric acid burns
- Burn injury in older adults (> 60 yrs)
- Burn injury with pre-existing medical conditions
- Burn injury with associated injury

SPECIAL CONSIDERATIONS

Burns and Respiratory Tract (Oxygen and ventilation)

Area	Manifestation
Supraglottic	• Loss of airway patency due to mucosal oedema • Loss of airway reflexes due to coma
Tracheobronchial	• Bronchospasm resulting from inhaled irritants • Mucosal oedema and endobronchial sloughing causing small airway occlusion
Pulmonary Parenchymal	• Pulmonary (alveolar) oedema and collapse leading to decreased compliance, and further intrapulmonary shunting • Loss of tracheobronchial epithelium and airway ciliary clearance contributing to tracheobronchitis and pneumonia

Table 3: Impact of burns and smoke inhalation on the respiratory tract

Furthermore, circumferential full thickness burns of the chest and abdomen may cause reduced static compliance resulting in restrictive ventilator defect.

Carbon Monoxide Inhalation (See IAEM Acute CO poisoning guideline)

CO gas is produced by the incomplete burning of fuel. It is poisonous. Breathing in a small amount can cause loss of consciousness and death. In Ireland about 40 people die from accidental CO poisoning every year.

Hb has a greater affinity for CO than O_2. The toxicity of CO thus results from displacement of O_2 from Hb, which leads to tissue hypoxia. After the CO has selectively bound to Hb, the oxygen-haemoglobin dissociation curve of the remaining oxyhaemoglobin shifts to the left, reducing O_2 release.

Note that the pulse oximetry may not be reliable if CO poisoning is suspected. Please refer to table 4 for symptoms of CO Poisoning.

COHb %	**Symptoms**
0-15%	None
15-20%	Headache, confusion
20-40%	Nausea, fatigue, disorientation, irritability
40-60%	Hallucinations, ataxia, convulsions, coma
> 60%	Death

Table 4: Symptoms related to COHb

Treatment

- Administer 100% FiO_2

Electrical Burns

Electrical Injury is dependent upon:

1. Power source (lightning or electrical)
2. Voltage (potential difference). High voltage >1000V or Low voltage <1000V (Domestic supply = 240V).
3. Current (amount of energy flowing)
4. Duration of contact
5. Type of current (AC or DC)
    - DC typically provides a single convulsion or contraction usually propelling person away from source
    - AC causes repeated convulsions and cardiac arrhythmias such as VF and is considered more dangerous
6. Contact: Damp or wet contact point (for example, hands) significantly reduces resistance to current

Electrical injuries can cause:

- Depolarisation of muscle cells: VF, sustained asystole, arrhythmias, myocardial damage, left ventricular dysfunction, tetanic contraction → fractures
- Vascular injuries: thrombosis, compartment syndrome → rhabdomyolysis
- Neurological injuries: peripheral nerve injury, coma, encephalopathy, autonomic dysfunction
- Renal injuries: myoglobinuria
- Other injuries: traumatic, fire, tympanic membrane perforation, cataracts, corneal injury

Electrical source	Likely injuries		
	Skin	**Deep tissue**	**Cardiac arrhythmia**
Low voltage **< 1000V**	Local entrance and exit wounds	Potentially can occur	Immediate cardiac arrest possible, otherwise nil
High voltage **> 1000V**	Flashover burn, full thickness entrance and exit wounds	Yes, especially muscle. Compartment syndrome, rhabdomyolysis	Transthoracic current may cause myocardial damage and delayed arrhythmias
Lighting (rare and life threatening)	Superficial or dermal flashover burns. Exit burns on feet.	Eardrum perforation and corneal damage	Respiratory / cardiac arrest - needs prolonged CPR

Table 5: Likely injuries due to electrical source

Utilise medical photography to document burns if possible**.** Please refer to table 6 for clinical manifestations associated with different electrical burns type.

Different type of electrical burns	Clinical manifestations
High-voltage electrothermal burns	• High risk of compartment syndrome (may require fasciotomy) • Contact point and ground point • May have very significant deep burn with skin sparing (**painless**, little bleeding) • Full thickness will have intact skin hairs (as opposed to flash or flame burns)
Arc burns (typically high voltage)	• Dry centre, cratering, surrounding oedema/erythema

	• Corneal injury- ophthalmological assessment needs to be documented
Flash burns e.g. due to burning rubbish with accelerant	• Due to intense heat from nearby arc • May "splash" over surface of body with superficial burn, no "electrocution"
Flame burns	• Nearby clothing etc. igniting with resulting thermal burn • Severity can vary from local superficial to full thickness

Table 6: Clinical manifestations associated with electrical burns type

Treatment:

- Check electrolytes and correct any electrolyte derangements.
- Admit those with chest pain / arrhythmia / abnormal initial ECG / raised troponin.
- Domestic electrocution with no cardiac complaints and normal ECG can be discharged.
- Fluid requirements in electrical injuries are likely to be greater in volume than would be anticipated in a pure cutaneous burn. Concealed muscle damage in the limbs will be responsible for fluid loss, which is not accounted for by the standard formula.
- Have a high index of suspicion for compartment syndrome in a patient who has disproportionate pain on passive movement of a limb.

In those patients with deep tissue damage, haemochromogenuria (dark red / black urine) is to be anticipated. A urinary catheter should be inserted both to detect the earliest sign of urine discolouration and to monitor urine output. If pigments appear in the urine, the infusion rate of fluids must be increased to maintain a urine output of 1-2 ml/kg/hr.

Chemical Burns (skin)

All chemical burns should be treated as deep burns until proven otherwise. Most chemicals that cause burns are as a result of exposure to acidic, alkaline or petroleum products such as:

- Ammonia
- Bleach
- Tar
- Metal cleaners
- Tooth-whitening products
- Oven Cleaner
- Pool chlorinators
- Drain or toilet bowl cleaners
- Concrete mix
- Battery acid

Assessment

- Emergency clinicians are advised to wear appropriate PPE.
- Check the pH.
- Consult TOXBASE® (The primary clinical toxicology database of the National Poisons Information Service, www.toxbase.org).

Treatment

- The chemical agent should be removed as early as possible.
- The involved clothing and footwear should be removed.
- Irrigation of the chemical by water lavage to dilute and remove the chemical.
- In case of burns from chemical powder, irrigation should not be started immediately as the water can activate the chemical – the powder should be dusted off first (carefully to avoid inhalation / further contamination) and then irrigation can take place.
- Periods of 30 minutes of copious irrigation for acid burns and even longer periods for alkali burns may be required.
- Irrigation can be repeated if required.
- Consider use of Diphoterine® solution. Diphoterine contains an amphoteric, chelating molecule: a substance which is capable of reacting with both acids and alkalis when

applied to either type of chemical spill, stopping the aggressive action of a corrosive or irritant chemical, halting the reaction with the body.

- Tar should be cooled with water but not peeled away from skin.
- Systemic toxicity is common after exposure to HF acid, petrol.

Hydrofluoric Acid

HF acid is HIGHLY TOXIC. It is used for etching glass and metal and to make refrigerants, herbicides, pharmaceuticals, high-octane gasoline, aluminium, plastics, electrical components, and fluorescent light bulbs. It readily penetrates intact skin / nails.

The fluoride ions bind to calcium leading to severe hypocalcaemia (as well as hypomagnesaemia, metabolic acidosis, and hyperkalaemia). ANY quantity can be dangerous and requires prompt evaluation and neutralisation.

Neutralisation with 10% calcium gluconate (refer to TOXBASE®). Aim for a pH between 5 and 8 on the skin.

Calcium gluconate gel can be made in the ED with a water-soluble lubricant, such as K-Y Jelly (Johnson & Johnson, USA), added to calcium gluconate solution (75 mL K-Y Jelly plus 25 mL of 10% calcium gluconate). The gel is applied every 30 min initially and massaged in; then applied every 4 hours.

Patient populations at risk for systemic toxicity include those with:

- Any burns with >50% HF acid concentration
- Exposure of ≥5% TBSA with any HF acid concentration
- Inhalation or ingestion of HF acid.

Emergency clinicians are advised to check electrolytes as the systemic effects are primarily related to electrolyte disturbances – mainly hypocalcemia, but also hypomagnesemia, acidosis, fluorosis and hyperkalemia.

Cyanide Poisoning

In fires, CN is produced when the temperature reaches 315°C and is released from the toxic fumes in gaseous form (i.e. HCN, which may then be inhaled by the patient). HCN results from the incomplete combustion of any material containing nitrogen such as plastic, vinyl, wool or silk. CN poisoning leads to cellular hypoxia.

CN intoxication should be suspected in a patient following exposure to a fire with smoke inhalation injuries if two or more of the following criteria are fulfilled:

1. Signs of neurological incapacitation such as altered mental status, unconsciousness, or convulsions.
2. Soot in the mouth or expectoration.
3. ABG reveals metabolic acidosis with a raised lactate, as the concentration of lactate increases proportionally to the level of CN poisoning.
4. There is an index of suspicion based on the history e.g. house fire involving soft furnishings.

Treatment

- The treatment of CN poisoning is aimed at basic life support including providing 100% O_2 and assisted ventilation if required (+/- intubation), decontamination, correction of acidosis and blood pressure support, as well as the use of an antidote.
- For decontamination, carefully remove any contaminated clothing (avoiding contamination of unaffected skin) and seal in a plastic bag. Wash contaminated skin with soap and water.
- **Antidote-** Hydroxocobalamin (Cyanokit®) should be considered in smoke inhalation victims who have a severe lactic acidosis, are comatose, in cardiac arrest or have significant cardiovascular compromise. Sodium thiosulphate is generally used as an adjuvant to other antidotes.

COMPANION DOCUMENTS

- Appendix 1 – Estimation of Burn Body Surface Area (Lund & Browder)
- Appendix 2 – Parkland Formula
- Appendix 3 – Recognising burn depth
- Appendix 4 – De-roofing blisters
- Appendix 5 – Dressing guidance as per Burn Unit in St. James's Hospital
- Appendix 6 – SJH transfer check list
- Appendix 7 - SJH Initial Management of Severe Burns Burns >15% TBSA in adults