the children's hospital at Westmead

BURNS PATIENTS IN PICU - CHW

PRACTICE GUIDELINE ©

DOCUMENT SUMMARY/KEY POINTS

- Collaborative approach to management is key to good outcomes in burns
- Avoid fluid creep – use multiple pieces of clinical information to titrate fluids
- Nutrition is a key part of recovery – burns patients should have this optimised and have fasting times minimised
- Optimising sedation & analgesia management, including non-pharmacological strategies are imperative in burns patients.
- Burns patients are at high risk for delirium and this should be aggressively prevented and managed

Approved by:	SCHN Policy, Procedure and Guideline Committee	
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Team Leader:	Intensivist	**Area/Dept**: PICU - CHW

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CHANGE SUMMARY

Document changed significantly, it is recommended to read in entirety.

- Several sections removed/significantly abbreviated and instead hyperlinked to the relevant institutional guideline: faecal management; perioperative fasting; sedation and analgesia; application of dressings
- Significant update to burns pathophysiology section
- Inclusion of a fluid management algorithm including approach to difficult resuscitation
- Addition of a section on infection and sepsis
- Significantly revised section on physiotherapy and early mobility

READ ACKNOWLEDGEMENT

- Clinical staff participating in care of burns patients in PICU

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Background

Burn injuries are the 3rd leading cause of preventable death in children worldwide and are an important public health problem. Roughly 1,000 children are admitted to an Australian and New Zealand Burns Unit for burn-related injuries each year, with 5-10% requiring admission to a Paediatric Intensive Care Unit.

Table 1: ANZBA Criteria for Referral to a Paediatric Burns Unit

Burn	Person	Mechanism
>5% TBSA	Complicating pre-existing illness	Major trauma
Full thickness burn		Chemical burn
Circumferential burn		Electrical burn
Burns affecting face, hands, feet, perineum or major joints		Inhalational Injury
		Suspected non-accidental injury

Over 80% of paediatric burn injuries occur at home, most commonly in the kitchen, with children living in conditions of social disharmony or disruption at higher risk (Figure 1). Scald burns are the most common, from hot beverages (19%), hot water from saucepans or kettles (15%) and hot food (10%) (Figure 2). In older children, flame burns are the most common, shifting to reflect the adult population.

Figure 1: Place of Paediatric Burn Injuries

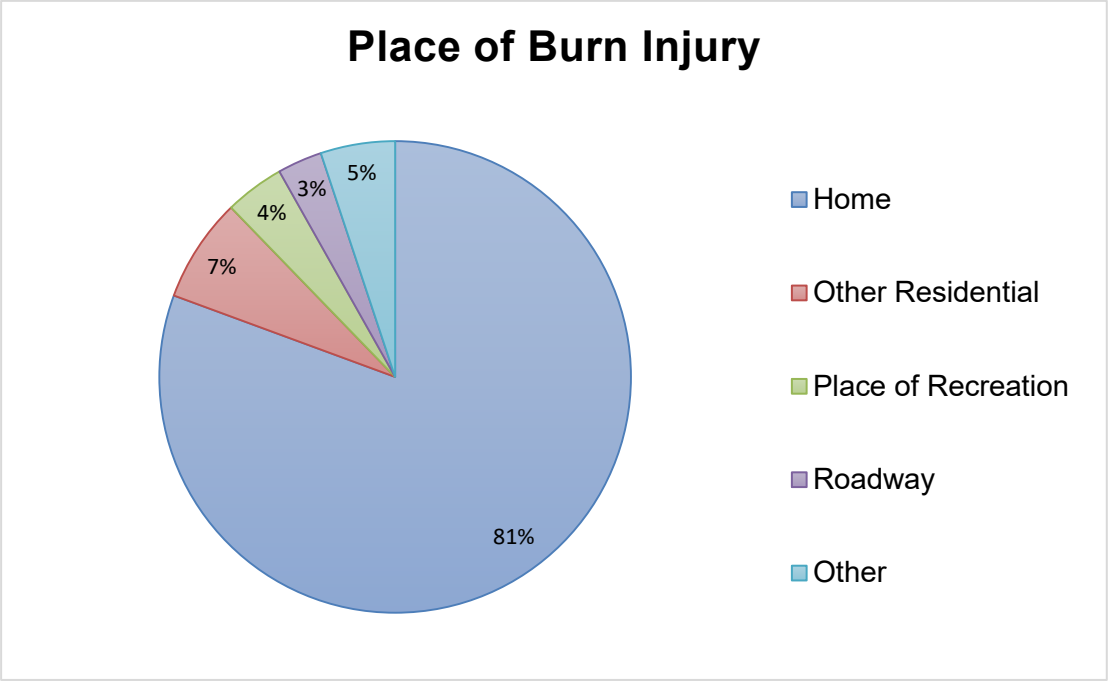
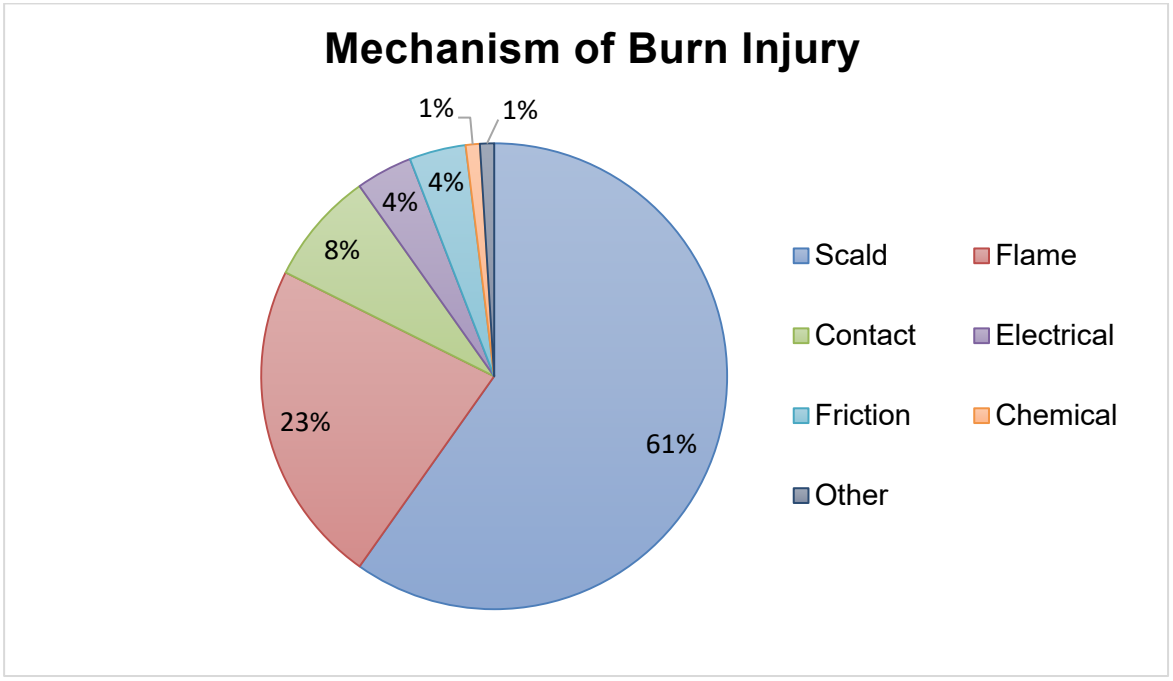
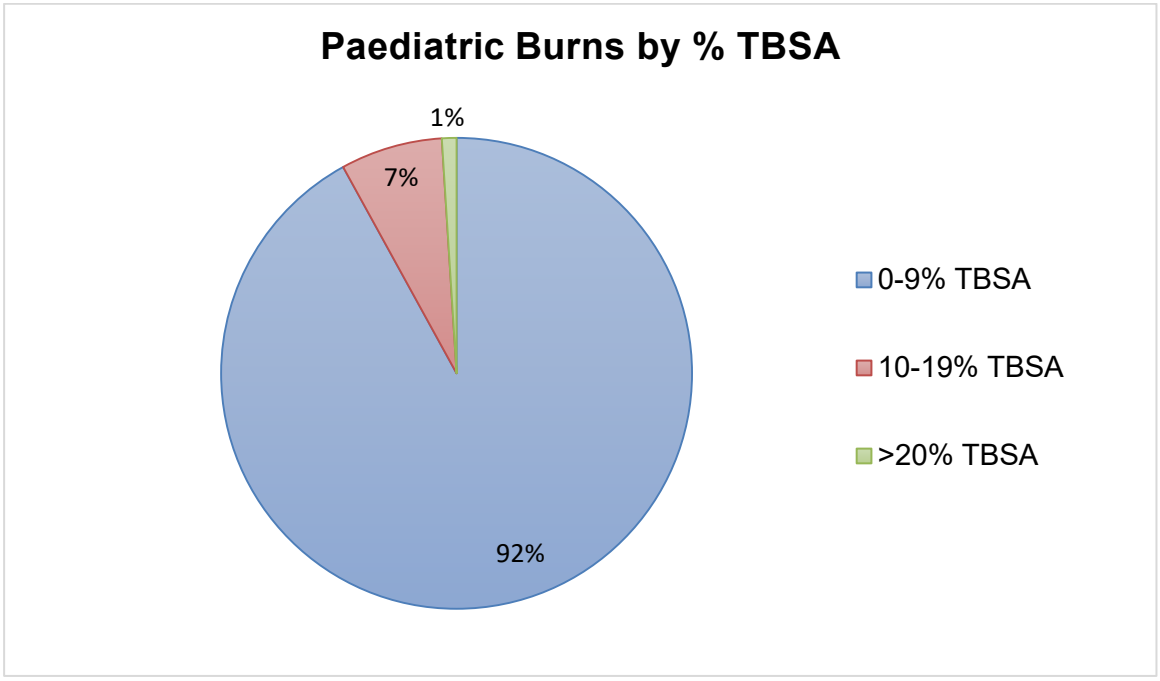


Figure 2: Mechanism of Paediatric Burn Injuries



The majority of paediatric burn injuries are minor (Figure 3). However, half of children with major burns (>15% TBSA) are admitted to a Paediatric Intensive Care Unit where a prolonged ICU stay is common (median 50-70 days).

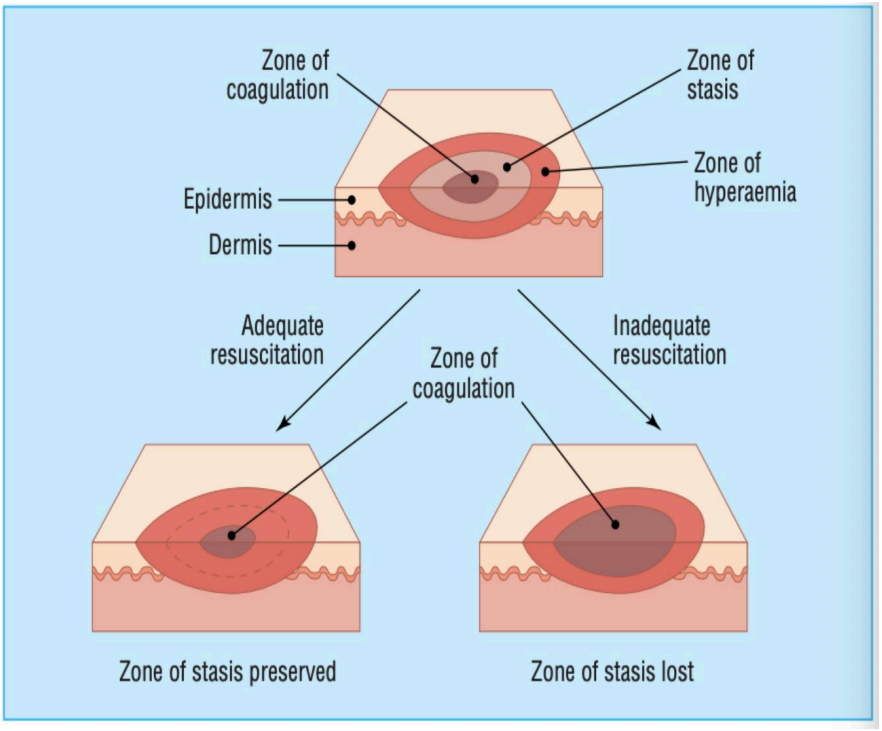
Figure 3: Paediatric Burns by % TBSA



Pathophysiology

Local Response to Burn Injury

Figure 4: Jackson's Burn Wound Model



Zone of coagulation - this is the primary site of burn injury and point of maximal tissue damage. It represents an area of irreversible tissue loss due to the coagulation of constituent proteins.

Zone of stasis – this surrounding zone is characterised by reduced perfusion and represents an ischaemic penumbra of potentially salvageable tissue. Good quality first aid and burn resuscitation aims to improve tissue perfusion and minimise progression to necrosis.

Zone of hyperaemia – this outer zone has increased perfusion and will heal.

Systemic Response to Burn Injury

Children with severe burn injury (>15% TBSA) can develop a profound systemic inflammatory response leading to multi-organ dysfunction.

Beginning from the time of injury, there is increased production and release of cytokines and pro-inflammatory mediators such as TNF-α and IL-6 from macrophages. Production of reactive oxygen species such as hydrogen peroxide and nitric oxide further induce a hypermetabolic state, producing changes in cellular metabolism that can persist for years following injury. Together, these inflammatory mediators, burn toxins and oxygen radicals cause multi-system injury.

Patients become severely vasodilated as a direct result of heat and inflammation. Increased vascular permeability leads to third spacing of intravascular proteins and fluids, causing hypovolaemia, hypoproteinaema and widespread oedema. Massive cytokine and catecholamine release also cause myocardial depression. The resulting hypotension and end organ hypoperfusion following severe burn injury – termed "burn shock" – is therefore a combination of hypovolaemic, distributive and cardiogenic shock.

Lung inflammation and bronchoconstriction is primarily mediated by free radical damage. Inhalational injury can cause pulmonary arterial hypertension, increased airway resistance, reduced lung compliance, atelectasis and pulmonary shunting. There is usually significant airway cast formation in inhalational injury. Diagnostic + therapeutic bronchoscopy should be considered for suspicion of inhalational injury.

An acute kidney injury secondary to renal hypoperfusion and acute tubular necrosis is common, as is impaired liver function from hepatocyte injury. Splanchnic vasoconstriction and intestinal hypoperfusion also lead to impaired gut barrier function, ileus and bacterial translocation.

Finally, the basal metabolic rate can increase up to three-fold, leading to catabolism, muscle wasting and malnutrition. Coagulopathy and thrombocytopaenia occur in up to a third of patients.

Assessment of Burns

An assessment of burn severity is performed by the Burns team on admission to hospital. Burn severity is dependent on the surface area and depth of the burn. Children are at high risk of severe burns due to their thinner skin and less developed avoidance reactions.

Calculating Burn Surface Area

The size of the burn is expressed in terms of percentage of total body surface area (% TBSA). Epidermal burns (erythema only) do NOT count towards % TBSA. Knowing the size is important as burns >15% TBSA in children are associated with a profound systemic inflammatory response with multi-organ dysfunction.

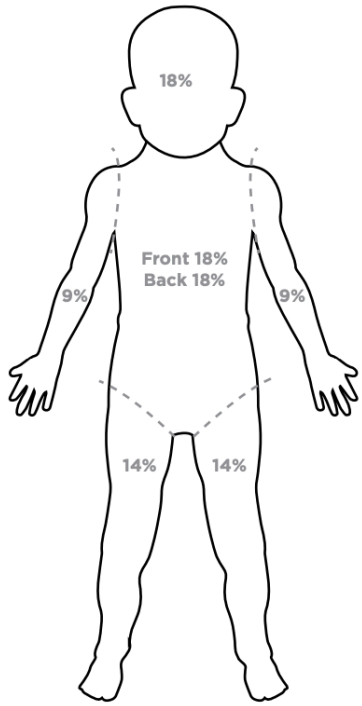
There are several methods of estimating the % TBSA:

Paediatric Rule of Nines

- The 'Rule of Nines' divides total body surface area into multiples of 9% and is a quick way of calculating % TBSA. Children have different body surface area proportions depending on their age

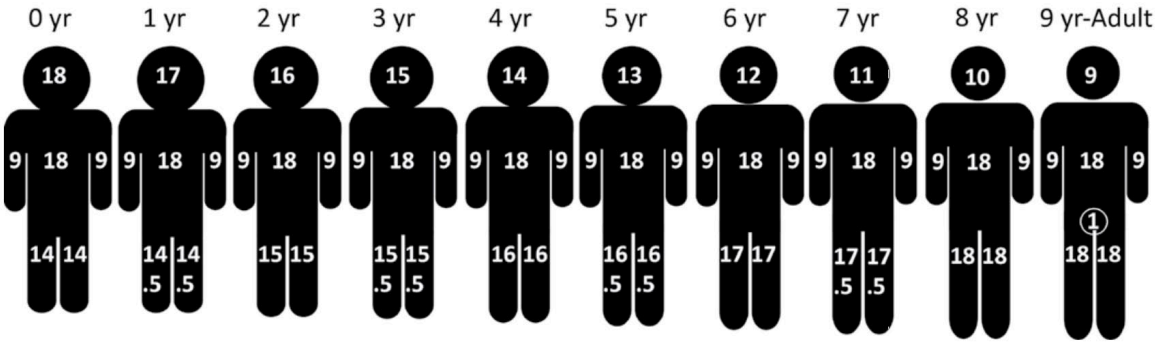
- Until 1 year of age, the head is 18%, each arm is 9%, each leg is 14%, the back is 18%, and the chest and abdomen are collectively 18% (Figure 5)

Figure 5: Body proportions for children under 1 year of age using 'Rule of Nines'



- For every year of life until 8 years of age, 1% TBSA is then deducted from the head and 0.5% TBSA is added to each leg. At 9 years, 1% is added to perineum and proportions become the same as an adult (Figure 6)

Figure 6: Changing body proportions with age using 'Rule of Nines'



Lund and Browder Chart

- The Lund and Browder Chart is another common method of estimating % TBSA due to its accuracy. Each body part has a specific % TBSA based on age as can be seen below (Figure 7)

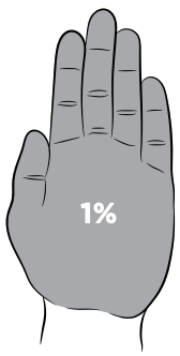
Figure 7: Lund and Browder Chart for estimating % TBSA burn according to age

% TBSA	0 - 1 yr	1 - 4 yr	5 - 9 yr	10 - 14 yr	15 yr	Adult	Total
Head (A)	19	17	13	11	9	7	
Neck	2	2	2	2	2	2	
Ant. Trunk	13	13	13	13	13	13	
Post. Trunk	13	13	13	13	13	13	
R. Buttock	2.5	2.5	2.5	2.5	2.5	2.5	
L. Buttock	2.5	2.5	2.5	2.5	2.5	2.5	
Genitalia	1	1	1	1	1	1	
R. Upper arm	4	4	4	4	4	4	
L. Upper arm	4	4	4	4	4	4	
R. Lower arm	3	3	3	3	3	3	
L. Lower arm	3	3	3	3	3	3	
R. Hand	2	2	2	2	2	2	
L. Hand	2	2	2	2	2	2	
R. Thigh (B)	6	7	8.5	9	9.5	10	
L. Thigh (B)	6	7	8.5	9	9.5	10	
R. Leg (C)	5	5	5.5	6	6.5	7	
L. Leg (C)	5	5	5.5	6	6.5	7	
R. Foot	3.5	3.5	3.5	3.5	3.5	3.5	
L. Foot	3.5	3.5	3.5	3.5	3.5	3.5	
						% TBSA total	

Palm of hand

- The area of the patient's palm (including digits) represents about 1% TBSA (Figure 8)
- This method is useful for measuring smaller, scattered burns.

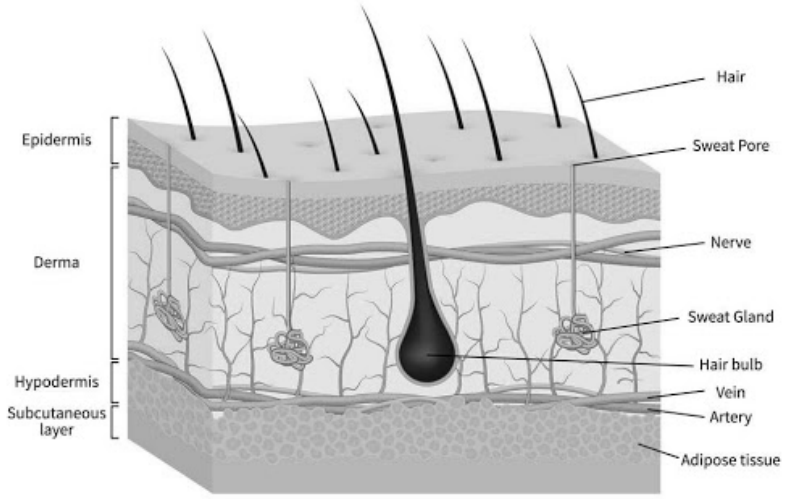
Figure 8: "Palm of hand" technique for estimating small % TBSA burns



Palmar, palm + fingers of patient = 1%

Assessing Burn Depth

Figure 9: Skin anatomy: the epidermis, dermis with associated adnexal structures, and subcutaneous tissue



Burns are classified as either epidermal, dermal or full thickness burns (Table 2). In practice, all burn injuries are a mixture of different depths, and can progress over time requiring serial assessment by the Burns team.

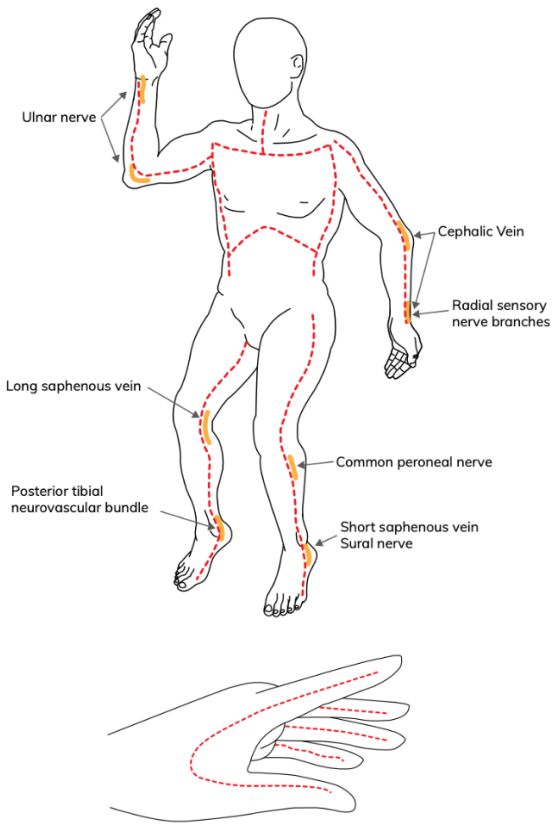
Table 2: Assessing Burn Depth

Depth	Pathology	Appearance	Capillary refill	Sensation	Blistering
Epidermal (e.g., sunburn)	Involves epidermis only	Dry, red and warm to touch	Brisk	Painful	None or delayed
Superficial Dermal	Involve epidermis and upper dermis; most adnexal structures intact	Pale pink	Brisk, hyperaemic	Hypersensitive, very painful	Large blisters within hours
Mid to Deep Dermal	Involves epidermis and most of dermis; only deep adnexal structures intact	Blotchy red or mottled	Sluggish or absent	Decreased sensation	Large blisters; can be absent
Full thickness	Epidermis, dermis and deep adnexal structures destroyed	Varied – red, white or charred. Eschar may be present, leathery to touch.	Nil	Nil	Nil

Circumferential Burns

- Deep dermal and full thickness burns can develop a rigid and inelastic layer of necrotic tissue called eschar
- In circumferential or near circumferential burns of the limbs, chest and abdomen, worsening oedema can cause a build-up of pressure beneath the inelastic eschar, causing circulatory or respiratory compromise
- All extremity burns should be elevated - if there are signs of poor perfusion despite elevation (pale, pulseless, perishingly cold, pain or numbness, reduced capillary refill), the Burns team should be contacted *immediately* for consideration of escharotomy
- Escharotomy may be performed prophylactically or to restore impaired circulation or breathing - this involves making an incision through the eschar to release pressure and in most cases will be performed by the Burns team (See Figure 7 for recommended incision lines, taking caution to avoid peripheral nerves)
- Circumferential chest burns can restrict chest excursion and compromise ventilation – consider escharotomy if high ventilator pressures, reduced air entry, shallow respiratory effort, tachypnoea or hypoxaemia
- Circumferential abdominal burns can also cause respiratory compromise by restricting diaphragmatic movement with children under 1 year particularly vulnerable with predominately diaphragmatic respiration - subdiaphragmatic transverse escharotomy may be required under these circumstances

Figure 10: Escharotomy schema



Management

When assessing the child on admission, remember that haemodynamic and respiratory status are of a higher priority than dressing the burn.

First Aid

- If within 3 hours of injury and there has been inadequate first aid, apply 20 minutes of cool running water to the burn which provides analgesia, attenuates cell damage, improves wound healing and minimises scar formation
- Do NOT use ice!
- Monitor closely for hypothermia – children are at higher risk of hypothermia due to their greater surface area to mass ratio and absent/reduced shivering reflex (absent under <1 year of age, reduced due to smaller muscle bulk)

Airway and C-spine Stabilisation

C-spine stabilisation:

- If the patient was unconscious at the scene or there is a history of actual or possible blast injury, continue C-spine precautions until a C-spine injury has been excluded
- Refer to SCHN Guideline - *Cervical Spine Immobilisation in ventilated patients in PICU*

Intubated:

- Securing the airway is priority
- For facial burns, it may be necessary to suture/glue the ETT to the teeth. An arch bar can be used to stabilise the ETT if the child is dentulous. Contact the dental team for assistance
- Confirm ETT position on chest x-ray (baseline chest x-ray should be ordered regardless of intubation status)

Not intubated:

- Assess airway patency
    - Does the patient have facial, oral or neck burns?
    - Are the neck burns circumferential?
    - Do they have singed nasal hairs/eyebrows, evidence of soot or carbonaceous sputum?
    - Does the patient have a hoarse voice?
    - Is the patient in respiratory distress?
    - Was the patient burnt in an enclosed space and at risk of inhalational injury?
    - Was the patient unconscious at the scene?
- High level of vigilance and consideration of early intubation due to risk of progressive airway oedema and obstruction in the presence of
    - Significant scald burns of the face and/or neck, particularly in the infant and toddler age group\
    - Elevated methaemoglobin/carboxy-haemoglobin level
- Airway oedema can develop rapidly in the first 6 hours especially with aggressive fluid resuscitation – monitor patient closely

- Occult upper airway obstruction in children is common
- Enlargement of adenoids, tonsils and laryngomalacia may precede burn injury
- Smoke inhalation can also trigger reactive small airways disease in children (bronchiolitis, asthma)
- If intubation is required in burns patients, anaesthetic involvement is advised

Breathing

- Assess breathing – respiratory rate, work of breathing, oxygen saturation
- Inspect and auscultate chest for signs of chest trauma – pneumothorax, haemothorax, rib injury
- Circumferential chest and abdominal burns may require escharotomy
- Assess for signs of inhalational injury – singed eyebrows or nasal hairs, carbonaceous sputum, soot, hoarse voice
    - Most patients, even those with severe inhalation injuries, will have little or no pulmonary dysfunction at initial presentation and the initial CXR is usually normal - ongoing careful monitoring is important
    - Can occur in the absence of cutaneous injury

Circulation and Fluid Management

- Establish IV access through unburnt tissue
- If needing central access, insert an appropriate central line - there is some evidence that antibiotic impregnated central lines decrease the incidence of bloodstream infection in paediatric ICU patients but the cost effectiveness/availability remains unresolved
- Insert an IDC for burns >10% TBSA to monitor fluid balance and urine output hourly
- Weigh the child on admission - accurate weight is important for fluid resuscitation (if an accurate weight is already known, this can be used)
- Monitor for signs of occult haemorrhage in patients with a high mechanism or blast injury
- If the patient is immediately shocked, it is unlikely to be due to the burn – exclude haemorrhage and other causes of shock, including spinal injury

Fluid therapy

- Optimal fluid resuscitation in major burns is challenging
- Inadequate resuscitation contributes to hypovolaemia and organ failure
- Excessive resuscitation contributes to fluid creep, extension of the burn wound and systemic oedema causing cardiorespiratory compromise, intra-abdominal and limb compartment syndrome

Resuscitation Fluids

- Children with >10% TBSA burns develop systemic inflammatory response syndrome necessitating aggressive fluid resuscitation
- The Modified Parkland Formula is used to guide fluid resuscitation over first 24 hours
    - Total fluid requirement in first 24 hours = 3mL/kg/%TBSA (+ maintenance fluids)
    - 50% of total is given in first 8 hours post injury
    - The other 50% is given over the remaining 16 hours

    - Calculations should be performed from the time of injury (NOT the time of admission)
- Use Hartmann's solution (Compound Sodium Lactate)
- In discussion with the PICU consultant, Plasmalyte may be considered for some patients
- After the first 12-24 hours, using albumin solutions for part or all of fluid resuscitation has been associated with decreased fluid creep and better outcomes in some studies and this can be considered on a case by case basis in discussion with the PICU consultant

The Modified Parkland Formula is a starting point only. Once admitted to hospital, fluid resuscitation should be titrated to a urine output of 0.5-1mL/kg/hour and clinical assessment by senior members of the ICU and burns teams

Titrating to urine output is crucial and prevents under and over-resuscitation from confounding factors such as inaccurate patient weight, inaccurate estimate of burn and overzealous resuscitation (fluid creep)

Use the Burns Fluid Algorithm (Appendix1)

- Certain situations are known to be associated with increased fluid requirements:
    - Very young age
    - Delayed resuscitation
    - Inhalational injury
    - Electrical injury

Maintenance Fluids

- Full maintenance fluids 0.9% NS and 5% dextrose should be commenced on arrival in addition to the above resuscitation replacement fluid
- Once the patient is able to tolerate enteral feeding this should be graded up to replace maintenance IV fluid
- Monitor closely for hypoglycaemia

Difficult fluid resuscitation

- If the patient is not responding to crystalloid therapy, 4% albumin can be added in the second 12h post injury
- Consider using difficult resuscitation and albumin protocol (**Appendix 1**) - discuss with the PICU consultant if this is required

Disability

- Perform routine ICU neurological observations
- Head of bed 30 degrees unless spinal precautions

- Burn patients have complex analgesia and sedation requirements - they should have pain, sedation, withdrawal, and delirium scoring done as per PICU sedation and analgesia guideline. Early involvement of the Acute Pain Service is recommended.
- There are some additional sedation & analgesia considerations for burn patients (see Sedation and Analgesia section below)

Exposure

- If possible, burns patients should be nursed in positive pressure rooms to minimise the risk of introducing infection
- Remove all jewellery, watches and piercings
- Once stable, perform a head-to-toe examination assessing for other non-life-threatening injuries
- Keep the patient covered to maintain normothermia
- Promptly change wet bedding or cooling cloths to avoid hypothermia
- All patients with limb burns require close neurovascular observations and limb elevation
- Children with facial burns should receive an Ophthalmology review to screen for eye burns

Sedation, Analgesia, Withdrawal, and Delirium

The PICU sedation and analgesia guideline should be followed; however there are some additional considerations.

- Early involvement of the pain service is recommended. Burns patients will usually be a Category 4 patient on discharge from PICU and should be handed over to the Acute Pain Service for ongoing management of their pain and associated weaning analgesia and sedation.

- As with all PICU patients, non-pharmacological therapies should be optimised. Engage child life and other allied health teams early. Engaging parents and other family members in cares and distraction activities should be prioritised.
- Burns patients have complex analgesia requirements and often require multiple adjunctive therapies. Ketamine infusions are often an effective adjunct.
- Gabapentin may be instituted at low dose to prevent and manage itch and may also be used at higher doses as an opioid sparing agent.
- Due to their prolonged sedation requirements burns patients are at high risk of developing tolerance. Burns patients often require prolonged intubation with intermittent surgical procedures for dressings and grafts. In between these episodes (which likely require increased analgesia and sedation) opportunities for weaning background sedation should be taken advantage of in order to decrease overall tolerance.

- Burns patients are at high risk for developing delirium - as with all PICU patients, dexmedetomidine or clonidine should be used first line for sedation, as they spare the dose of benzodiazepines, are an excellent analgesic adjunct, and may prevent and treat delirium

Procedural sedation for burns dressing changes

- Dressing changes are usually done in theatres or the Emergency Department however it is often appropriate for these to be done in PICU
- Ketamine sedation plus an opiate is a safe and effective combination of medications for most patients. As with all procedural sedation in PICU, the approach for the individual patient should be discussed with the PICU consultant on; and adequate staff for managing the sedation and monitoring the sedated patient must be available as per our usual practice.

Refer to Section 11 Procedural Sedation, page 19 of the Analgesia and Sedation – PICU - CHW guideline.

Wound Management

- Effective wound management following a burn injury is imperative to help facilitate wound healing within ideal timeframes in order to achieve optimal outcomes
- Knowledge of the dynamic and evolving nature of a burn wound and an understanding of different types of burns dressings and their actions will help facilitate good wound management

Initial burn wound care goals

1. Cool the burn wound (20 minutes of cool running water is gold standard for first aid)
2. Clean and cover the burn wound in order to minimise heat loss & risk of infection

   - Remove any restrictive jewellery

   - Take burn wound swabs from each anatomical location

   - Take digital photographs on admission
3. Apply a simple non-adherent dressing

   - Cling film may be placed in sheets over the burn wound but do not wrap circumferentially around limbs or the torso or apply over the face

   - Sheets of Bactigras or Jelonet dressings may also be used until a burn wound assessment is attended to

   - Facial burns may be left exposed and have topical soft white paraffin applied

- The Burns Team will determine if a patient needs to have their initial clean and application of dressings in the operating theatre environment, or be suitable for application of dressings at the bedside. If dressings are to be done at the PICU bedside, there is a Burns specific dressing trolley in PICU that should be used for this purpose.
- Definitive wound management will occur once the Burns team have conducted a formal burn wound assessment (including TBSA% & depth)

Ongoing burn wound management goals

1. Promote burn wound healing
2. Minimise pain and promote patient comfort (wound exudate and odour management)
3. Minimise risk of infection
4. Facilitate normal movement and function
5. Facilitate timely wound healing in order to achieve optimal functional and cosmetic outcomes

- Patients who have large surface area burn wounds that are deep dermal or full thickness in depth will require multiple surgical procedures throughout their PICU admission -these procedures will occur over weeks to months and may include:
    - Staged excision of the burn wound and temporary wound closure
    - Debridement and application of split skin grafts
    - Use of dermal substitutes

- Patients in PICU are likely to have a variety of different wound management needs for different wound sites requiring a combination of multiple wound dressing products at any one time – e.g. a patient may have areas of intact burn eschar dressed with Acticoat, debrided burn areas covered with Biobrane, grafted areas dressed with Bactigras and donor site areas dressed with Mepilex
- Individual patient plans for burns dressings will be guided by the Burn team and communicated to the PICU team
- Following completion of dressings in PICU please ensure:
    - Patient is appropriately positioned (follow guidance from Burns Physiotherapist) - elevate affected limbs to minimise oedema formation
    - Patient is placed on clean dry sheet - for patients with large TBSA% burn injuries consider use of large Blueys or an Exu-Dry sheet for greater absorbency of wound exudate
    - Dressing procedure is documented - including findings and ongoing wound management plan

Dressing products

Appendix 2 is a list of current burns dressing products used by CHW Burns Service and SCHN Network (description/action/clinical use). For more comprehensive application instructions please refer to Section 6 of the SCHN Burns Management Practice Guideline.

Dermal Substitutes

Matriderm

- A collagen elastin matrix used for dermal regeneration
- Derived from bovine dermis and ligaments
- May be used in the surgical treatment of acute full thickness burns or traumatic injuries
- Also used for reconstruction of deep dermal / full thickness defects or chronic wounds
- Aims to improve the quality of the skin, reduce scarring, prevent contracture and restore function
- Applied in a one-step procedure to debrided wound bed, immediately covered with a split thickness skin graft
- As healing progresses, the patient's own fibroblasts will eventually produce their own collagen matrix while Matriderm is resorbed

Biodegradeable Temporising Matrix (BTM)

- Polyurethane foam with sealing membrane attached
- Aims to improve long term functional outcome and appearance of burn scar as well as improve pliability and elasticity of newly healed skin
- Used in the management of acute deep dermal and full thickness burns along with reconstruction procedures
- BTM is applied to a surgically debrided wound bed. It then undergoes a process of integration whereby the BTM becomes infiltrated with haemoserous fluid and cellular material providing a scaffold for the neo-dermis to develop. This integration process may take up to 3-6 weeks. During this time the patient will require weekly to twice weekly dressing changes. NPWT dressings may be applied over the BTM
- Once integration is complete, the BTM is fully vascularised and ready for delamination. At this stage, the patient will return to theatre for removal of the sealing membrane and application of a split skin graft

Infection & Sepsis

Sepsis is a leading cause of death in patients with significant burns. They are at high risk of sepsis due to the loss of skin barrier; a dysregulated immune response as part of the systemic manifestation of major burns; and their need for prolonged intensive care including central access, ventilation, and other invasive procedures and devices.

The diagnosis of sepsis is difficult in burns patients for multiple reasons:

- The systemic inflammatory response to burns mimics sepsis
- Inflammatory markers such as Procalcitonin and CRP are not as reliable in burns patients
- White cell count is often raised in burns, even if infection is not present

Because of this, burns patients have historically often been excluded from research trials on sepsis, meaning that the evidence base for preventing and managing sepsis in this group of patients is less robust than for other intensive care patients.

Infection prevention and control

- Strict aseptic technique when doing procedures, and strict adherence to all usual infection control measures is of utmost importance
- Intravenous lines should be placed through unburned skin and as remotely from burn injuries as possible. Daily consideration of rationalisation of all invasive devices should be carried out

Diagnosis and management of infection/sepsis

- There is a difficult balance to draw in burn patients of not overtreating for infection (which increases the risk of multi-drug resistant organisms and exposes the patient to the complications of antibiotic therapy) and also ensuring that we promptly treat what is a common, and life threatening problem in this patient group. Early involvement of senior medical staff is essential.
- In addition to commencing antibiotics, suspected burn sepsis must be collaboratively managed with the burn team for surgical source control and ongoing surgical management of the burn.
- Prophylactic antibiotics should not be administered.
- Before commencing antibiotics for suspected sepsis, all patients should be pan-cultured, including a peripheral blood culture if possible.
- Fever, on its own, is not sensitive or specific for infection in burns patients. Any patient with a fever >38.5 and new haemodynamic instability should be cultured and commenced on broad spectrum antibiotics, after discussion with the PICU consultant/fellow.
- Other parameters that may suggest infection:
    - progressive tachycardia

- progressive tachypnoea
- thrombocytopaenia (from three days post-burn)
- persistent hyperglycaemia
- feed intolerance

- The principles of antibiotic therapy in burn patients with suspected sepsis as the same as for other PICU patients. Broad spectrum antibiotics covering the most likely organisms should be commenced with the goal of rapidly narrowing the spectrum on the basis of culture results.
- Burn wounds are usually initially colonised with gram positive organisms. From about 7 days post burn, these begin to be replaced by gram negative organisms. This should be taken into account when choosing empirical agents. Always discuss the antibiotic choice with the PICU consultant. Early involvement of the infectious diseases team is often appropriate.
- Therapeutic drug monitoring is essential in burns patients as the pharmacokinetics of many common antibiotic agents are altered in burns.

Nutrition

Nutrition intervention is an important component of burn management. All burns patients in PICU have a blanket referral to dietetics. Early and regular dietitian review is required to ensure the patients' high nutritional requirements are met.

Enteral feeding:

- All patients with >15% TBSA burn or significant facial burns of any percentage should have a nasogastric tube (NGT) and transpyloric tube (TPT) inserted on admission to PICU - this facilitates optimal medication administration and enteral nutrition in major burns patients as dressing changes and theatre visits are likely to be numerous
- Aim to commence enteral nutrition within the first 6-12 hours of admission (1) - early enteral feeding is thought to improve splanchnic perfusion, preserve gut mucosa, prevent bacterial translocation and attenuate the catabolic response after thermal injury
- Due to vasopressor support and muscle relaxation, patients are at risk of poor gut perfusion - as a result they may not tolerate full maintenance enteral feeds within the first 24 hours. It is important to persist with enteral feeds and expect relatively large residual volumes
- **As a rule, we do not cease enteral feeds for theatre if the patient is intubated or if feeds are well tolerated via a TPT (See Fasting guideline for children having general anaesthesia - CHW Section 8.3 page 9)**
- Monitor BSLs 6th hourly - elevated catecholamine levels from stress response mechanisms may cause initial hyperglycaemia which impairs wound healing - if persistently hyperglycaemic, discuss insulin therapy with PICU consultant

Choice of feed:

- If unable to consult with the dietitian prior to commencing enteral feeds refer to the table below for the appropriate feed choices:

Infant 0-12 months	Toddler/Child (> 1 year and >8kg)	Child/Adolescent (> 6 years and >20kg)
EHM or Standard infant formula (Nan Optipro RTF)	Nutrini (1kcal/mL)	Osmolite (1kcal/ml)

- The dietitian will review the need for specialised formula, for example:
    - Hydrolysed formula if poor tolerance to standard formula
    - High energy formula if patient not meeting estimated energy requirements within fluid allowance
    - Formula with added protein if not meeting estimated protein requirements
    - Formula with added fibre to assist with regularity of stools

Micronutrient requirements:

- In patients with major burns, micronutrient requirements are increased, however the dose and type of supplementation is not currently well defined in paediatrics
- Micronutrient requirements should be discussed with the dietitian and burns team, and ongoing modification during admission may be required
- It is important to consider micronutrient provision from other sources such as enteral and parenteral nutrition

The following recommendations have been made based on current literature and in consultation with the PICU pharmacist and dietitian (1, 2, 3, 4):

- Recommended supplementation for burns 10-15%:

Multivitamin Route: PO	< 1 yrs: 1-3 yrs: 3-12 yrs: > 12 yrs:	Pentavite Infant Drops 0.45mL daily Pentavite with Iron 3.5mL daily Centrum Kids Chewable, 1 tablet daily OR Pentavite with Iron 5mL daily Centrum Kids Chewable, 1-2 tablets daily

- Recommended supplementation for burns >15%:

Multivitamin Route: PO	< 1 yrs: 1-3 yrs: 3-12 yrs: > 12 yrs:	Pentavite Infant Drops 0.45mL daily Pentavite with Iron 3.5mL daily Centrum Kids Chewable, 1 tablet daily OR Pentavite with Iron 5mL daily Centrum Kids Chewable, 1-2 tablets daily
Selenium Route: PO	**1-3 yrs**: **3-10 yrs**: **> 10 yrs**:	12.5microg daily or BD 25microg daily or BD 50microg daily or BD

(Selemite B 100 microg tablets)	Note: - It may take up to 7 days for levels to increase - Enteral feeds & TPN will contain selenium, zinc and other trace elements - Maximum 400microg/day from all sources
Zinc Route: PO	1mg/kg/day elemental zinc in 1-3 divided doses - Max dose 30mg daily Zinc sulphate 20mg/mL solution contains 4.5mg/mL of elemental Zinc
Vitamin C Route: PO	**1mo-3 yrs: 125-250mg/day, given 12 or 24 hrly** **4-11 yrs: 250-500mg/day, given 12 or 24 hrly** **> 12 yrs: 500-1000mg/day, given 12 or 24 hrly** **Caution: risk of developing acute or chronic oxalate nephropathy with high dose therapy in renal impairment or patients prone to recurrent renal calculi.**

- Note: Enteral Copper supplementation is not currently available. If serum Copper levels are low, liaise with the pharmacist and dietitian regarding alternative options (for example addition of a complete multivitamin containing copper such as Paediatric Seravit or Fruitivits).

Nutritional Biochemistry:

- For those with burns >15% or in those who have demonstrated poor wound healing, nutritional biochemistry should be monitored regularly (approximately once monthly) – liaise with the dietitian re frequency of monitoring required:
    - Vitamins: A, E, D, C, B12, Folate
    - Trace elements: Copper, Selenium, Zinc
    - Minerals: Iron studies
    - CRP (as the inflammatory process may affect micronutrient levels – interpret results with caution if CRP elevated)
- Children with burns are at increased risk of fractures after discharge – ensure vitamin D levels are monitored regularly and provide supplementation as indicated

Anthropometry:

- Weight and height should be measured on admission if clinically appropriate (with weight measured prior to fluid resuscitation if possible)
- Weight should be measured regularly during admission – aiming twice weekly on Monday and Thursday

Bowel management:

- Unless there is a contraindication, stool softeners and aperients should be charted at admission - burns patients are at high risk of gastrointestinal disturbance and gastroparesis from high opiate dosing, fluid loss and immobility
- Dietitian to consider addition of fibre to feeds to assist with constipation if indicated
- Management of diarrhoea in patients with perineal or lower back burns may necessitate insertion of a rectal tube to prevent wound contamination (see faecal management and rectal irrigation section below)

Faecal management and rectal irrigation

Refer to SCHN Burns Management practice guideline Appendix 6: Faecal Management and Rectal Irrigation page 55-56.

Other

Clarify history

Scald burn	Temperature Nature
Chemical burn	Composition Concentration Discuss with toxicology?
Electrical burn	Voltage Current
Mechanism & History	Fit injury pattern? Child protection concerns?

Tetanus

- Tetanus immunity status should be established as soon as practical after the injury
- If the patient has not received a tetanus injection in the last 5 years OR the patient has not received the full course (3 spaced doses) of tetanus injections, a booster should be administered

Physiotherapy and mobility

- Physiotherapy is a vital part of the multidisciplinary team managing the burns patient in the PICU
- Rehabilitation of all burn injuries is initiated from admission to hospital with all therapeutic interventions aimed at preventing the known consequences of a paediatric burn injury
- The specialised burns physiotherapist is responsible for all aspects of early scar management in the PICU including positioning, splinting, stretching, mobility and exercise to maximise long term functional recovery following a burn injury
- Interventions and recommendations are individualised, considering the location and nature of the burn, as well as the stage of healing or grafting where required
- The specialist burns physiotherapist should be contacted as soon as possible after a child is admitted to the PICU with a burn injury - the PICU physiotherapist is responsible for handing over care to the specialist physiotherapy team; the burns CNC is also able to contact the specialist burns physiotherapist
- The specialist burns physiotherapist will continue to review the patient while they remain in PICU and, as appropriate, may also review the wounds +/- grafts at the time of dressing changes and provide therapy as required
- To enhance communication, the specialised burn physiotherapist will either attend the daily PICU allied health huddle (Mon-Fri 11am), or provide a direct handover to the PICU physiotherapist

Splinting

- Custom made splints are commonly used to prevent the development of burn scar contractures and to maintain optimal positioning of affected joints
- Splints may be fabricated using plaster of Paris or thermoplastic material and are in an intentional end of range position - they can be designed to remain in situ constantly or removed for prescribed periods of time, dependant on stage of healing and therapeutic goals
- Burn scar contractures develop rapidly and can be difficult to reverse if intervention is not timely - t is essential that splinting regimes are strictly adhered to, with all concerns regarding swelling, circulation, pressure or splint tolerance, or variation to regime discussed with the specialist burns physiotherapist - the burns physiotherapist will continue to monitor the splint and regime and adjust as appropriate
- Patients with facial burns may require special mouth splints +/- stretches - it is important that management of facial burns is clearly discussed and prioritised
- Mouth contractures can have serious long term consequences if not prospectively managed impacting airway protection, speech, dental hygiene and management of a normal oral diet

Positioning

- Patients may have specific positioning instructions to optimise dressing contact and healing potential, manage limb oedema, avoid pressure areas and prevent burn scar contracture - the specialist burns physiotherapist will advise on optimal positioning and create a positioning plan in conjunction with the PICU team
- Important factors to consider include, but are not limited to:
    - degree of oedema
    - burn location
    - stage of healing/grafting
    - ventilation
    - lines and attachments
    - pressure areas
- The flexor or concave joint surfaces are at highest risk of burn scar contracture - these include the anterior neck, axilla, anterior elbow joints, anterior hips, anterior ankles and dorsum of feet, palmar surfaces of the hands and posterior knees
- Neck burns are especially challenging to manage and can result in significant complications if the burn scar contracts
    - these patients must not have a pillow under their head as this flexes the neck and encourages contracture
    - elevate the shoulders on a blanket roll so the neck is encouraged into extension
    - where it is important for the head to be elevated to assist in managing swelling or respiratory complications, a full bed tilt is recommended to preserve optimal anti-contracture positioning
    - these patients will be fitted with a soft neck collar by the specialist burns physiotherapist in order to maintain extension of the neck -timing for the neck collar is dependent on the degree of swelling, security of the ETT or presence of a tracheostomy and ventilation considerations

Pressure area care

- The specialist burns physiotherapist must be consulted for pressure area care prevention and management, as specific positioning, splinting and contracture management is an important consideration
- The specialist burns physiotherapist will prescribe all positioning regimes with consideration to minimising pressure and provide advice regarding any burns specific pressure care concerns

Prone positioning

- In cases where significant debridement or grafting is required on the patients back or posterior thighs, the patient may be required to be nursed prone for the period between grafting and the first change of dressing post op (typically 5 days)
- It is important that these patients are identified early so a custom made prone mattresses can be provided by the specialised burns physiotherapist - for safety, when a prone mattress is in use, a thinner mattress may be recommended
- Communication is vital in these patients to balance an often complex therapy regime with competing acute care needs

Exercise & mobility

- As appropriate, passive stretches will be prescribed to assist in maintaining joint range - these exercises can be performed by the specialist burns physiotherapist, PICU staff or family members
- Progression of exercises from passive to active, as well as mobility progression, should be driven by the specialist burns physiotherapist, in consultation with the PICU team
- Early mobility should continue to be encouraged, taking into consideration the complex management of the burns patient

Chest physiotherapy

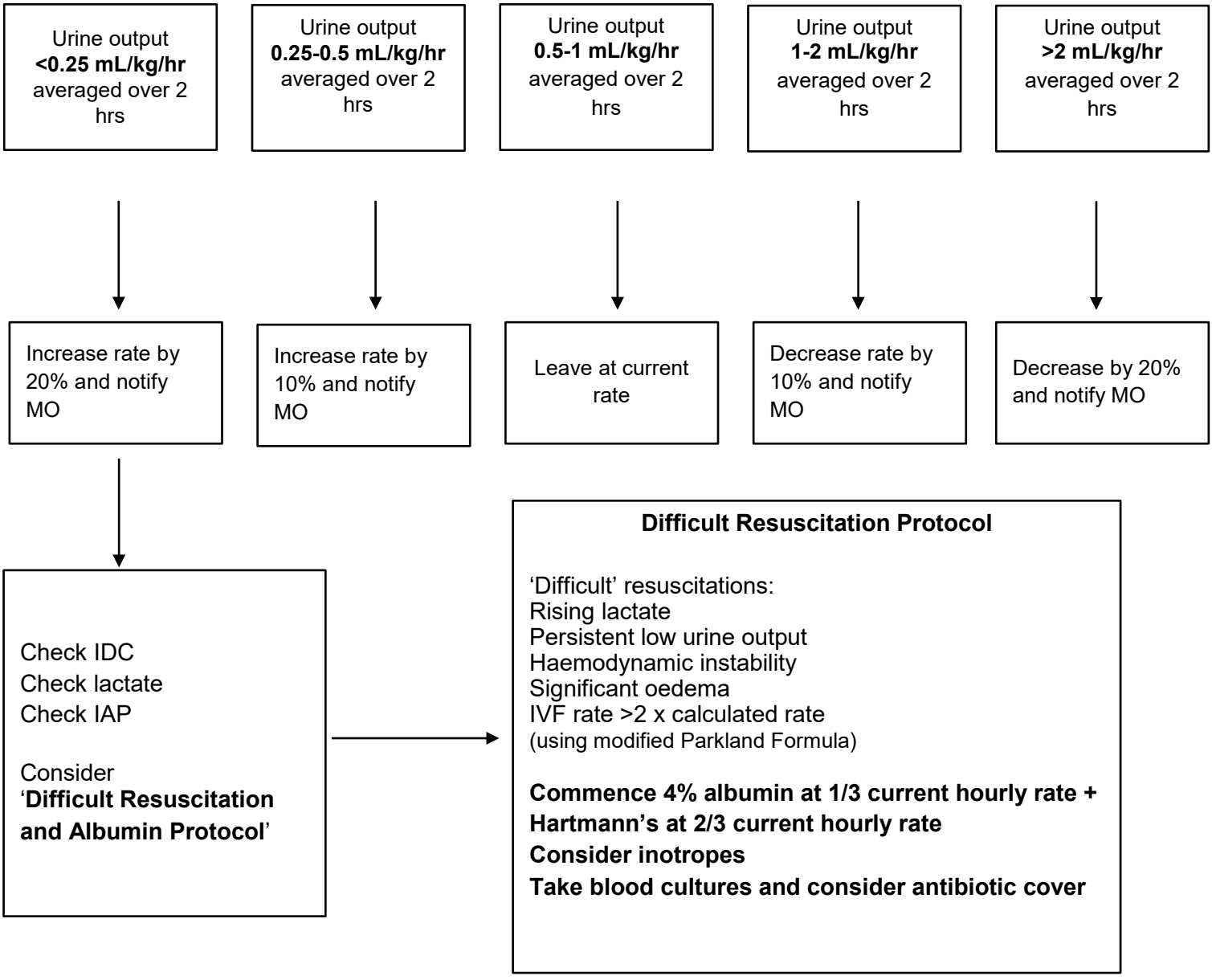
- The acute systemic response to a burn injury can include respiratory compromise
- Chest physiotherapy may be indicated for patients who have difficulty clearing or managing secretions, have acute CXR changes or difficulty ventilating or weaning from ventilation
- Referral for chest physiotherapy should be through normal processes, with either a verbal referral at the daily PICU allied health huddle (Mon-Fri 1100am) or via page #6189
- Some standard airway clearance techniques may be contraindicated at some stages of wound healing and the suitability for manual techniques should be assessed and discussed on a case by case basis
- The treating therapist should liaise with the specialised burns physiotherapist if there are any concerns

Psychosocial Considerations & What to Tell the Family

- Contact the designated Burns Social Worker (page #6501 - this pager is routinely carried during normal working hours but, should any difficulties be encountered, please contact the Social Work Department)
- Ensure parents and siblings are offered crisis intervention counselling and support from the Burns social worker +/- pastoral care teams - both are available through switchboard 24 hours a day
- The family may have many questions about their child's burn injury including depth of the burn, the need for grafting and the potential for scarring – remember that predictions about treatment or outcome **cannot** be made early in the child's admission
- Caution is advised even if you believe that there is some optimism about depth of the burn injuries - it is better for the parents to understand that early predictions cannot be made but that they will be kept informed as the burn depth and treatment plans evolve
- Be prepared for a wide range of responses – some people may be horrified by the way the child looks and feel overwhelmed by their emotions - some families may initially only be able to look through the doorway
- Common emotional responses include guilt about the circumstances of the burn, anticipatory grief about the loss of the physically perfect child or the fact that the child may die - there may be strong feelings of anger and blame between the parents or extended family members, particularly towards the carer responsible for supervision at the time of injury
- Many families will present with distressing post-traumatic stress reaction (PTSR) symptoms - the Burns Social Worker can provide parents with psychoeducation about these symptoms as well as strategies to manage them
- Siblings should not be discouraged from visiting; however, they should have pre and post visit counselling to help them to cope with their experiences - if a parent does not want siblings to visit, offer rationales for visiting but remember whose children they are
- Parents of paediatric burn survivors are known to have high rates of emotional and physical distress including guilt, depression and anxiety which may have a negative effect on the child's ability to tolerate burn pain
- Parents will be encouraged to participate in burns dressings, particularly once discharged to the burns ward (Clubbe) - they may not feel ready to take on this role in PICU

Appendix 1 Fluid Resuscitation Algorithm

- This algorithm should be used to titrate resuscitation fluids (Hartmann's) in the first 24 hours
- Maintenance fluids (0.9% sodium chloride and 5% dextrose) should not be adjusted using this algorithm
- Consider higher urine output targets with electrical/crush injuries, or evidence of rhabdomyolysis or reduced end organ perfusion



Appendix 2 Dressing products

Product	Description	Application indication	How to apply	Sizes
Acticoat® **Acticoat 7®**	Silver antimicrobial barrier dressing. Provides sustained release of silver onto wound bed over 3 or 7 days. Must be kept moist.	**OVER DEBRIDED NON GRAFTED AREAS**	Wet in bowl of sterile water for irrigation shortly before use. If soaked for too long, silver will soak out of dressing	Standard Acticoat (3 day) Acticoat 7 (7 day) Both available in various sizes
Mesorb®	Contains an absorbent core of cellulose pulp sandwiched between a non-woven wound contact layer and textured fluid resistant layer	**OVER ACTICOAT TO PROVIDE MOIST RESERVOIR**	Moisten in bowl of Sterile Water for Irrigation and squeeze out excess moisture. Apply over Acticoat layer. **Do not apply sodden**	Available in various sizes
Mepilex Ag®	Antimicrobial absorbent polyurethane foam containing silver with silicone based wound contact layer.	**ACUTE SUPERFICIAL TO MID DERMAL WOUNDS.** **DONOR SITES WHEN INFECTION PRESENT.**	Remove plastic backing sheet and silicone wound contact layer against wound surface. *Do not stretch.* Aim to overlap donor site area by at least 2cm. Secure in place with Hypafix strips	Sheets boxed in various sizes
Mepilex® **Mepilex Lite®**	Absorbent polyurethane foam with silicone based wound contact layer Thinner version of Mepilex foam	**DONOR SITES** **SUPERFICIAL BURNS, END STAGE GRAFT HEALING**	Remove plastic backing sheet and apply silicone wound contact layer against wound surface. *Do not stretch.* Aim to overlap donor site area by at least 2cm. Secure in place with Hypafix strips	Sheets boxed in various sizes
Bactigras®	Woven gauze dressing impregnated with antiseptic soft paraffin	**TEMPORARY DRESSING OVER ACUTE BURN WOUNDS & POST SKIN GRAFTING**	Remove waxed paper and use straight from roll or packet. Apply in a double layer.	Rolls and sheets in various sizes

Jelonet®	Woven gauze dressing impregnated with soft paraffin	**OVER GRAFTS WHEN CEA CELL SPRAY IS USED**	Remove waxed paper and use straight from roll or packet	Rolls and sheets in various sizes
Mepitel®	Non-adherent fine silicone mesh silicone dressing, coated with silicone gel	**OVER SKIN GRAFTS**	Remove backing & apply to wound	Sheets boxed in various sizes ***NOT STOCKED ON CC OR BPTC****
Biobrane®	Semi-permeable biosynthetic dressing consisting of a bilayer of silicone film and nylon mesh membrane coated with porcine collagen	**TEMPORARY WOUND COVERAGE FOR EXCISED DEEP DERMAL & FULL THICKNESS BURNS** **DEFINITIVE DRESSING FOR MID DERMAL BURNS & FACAIAL BURNS**	Apply straight from packet with fabric (dull) side down	Sheets boxed in various sizes
Webril®	Stretchable cotton bandage with absorbent properties	**TO SECURE DRESSINGS, PROVIDES ABSORBENT PROTECTIVE LAYER UNDER CREPE**	A) Wrap firmly around underlying dressings B) Soak in sterile water and wrap around underlying Acticoat dressing – only when circumferential burn.	2", 3", 4", 6"
Crepe®	Lightweight woven bandage	**TO SECURE DRESSINGS**	Wrap firmly around underlying dressings & webril, and secure with staples, Hypafix or Elastoplast.	1", 2", 3", 4" & 6"
Conforming gauze bandage	Lightweight woven bandage (thin, elasticised)	**TO SECURE FINGER AND HAND DRESSINGS**	Following application of primary dressing and webril layer, individually wrap each finger and hand.	1", 2"
Exudry® Vest	Non-occulsive, highly absorbent vest shaped dressing with a rayon/cellulose blend layer sandwiched between polyethylene layers.	**OUTER BURN WOUND DRESSING LAYER** **MAY BE USED AT ANY STAGE**	Wrap patient with underlying dressings in vest, securing with ties and bio-occlusive dressings	Paediatric small, medium and large. Please consider the size of underlying dressings before selection
Hypafix®	Self-adhesive, non-woven polyester fabric	**TO SECURE PRIMARY DRESSINGS AND PROVIDE FIXATION**	Remove backing paper & stretch out & apply sticky side to wound.	Available in sterile packets from CSSD (various sizes) or non-sterile

				rolls. May be cut into strips to secure dressings and bandages.
Opsite®, Tegaderm®/ Ioban®	Bio-occlusive dressing/ impregnated with iodine	**TO SEAL ACTICOAT DRESSINGS AND WATERPROOF EXTERNAL BANDAGES (UPPER THIGHS, BUTTOCKS, PERINEUM)**	Cut to size needed and remove backing paper then apply sticky side to wound	Sheets boxed in various sizes
NPWT dressings **(VAC / PICO)**	Negative pressure wound therapy designed to apply localised negative pressure (suction) to a patient's wound site.	**OPTIMISE WOUND HEALING.** **Stimulates formation of granulation tissue, removes excess fluid oedema, aides in wound contraction and can increase vascular perfusion**.	• Thoroughly cleanse wound • Cleanse and dry the peri-wound area • Apply Comfeel to protect the peri-wound •Cut the VAC® foam to the wound dimensions. • Gently place foam into the wound cavity - avoid contact on the peri-wound skin. Avoid use of staples for fixation. • Place appropriately sized VAC® adhesive drape over foam, allow a 3 – 5cm overlap border. • Cut a small hole in the drape directly over foam, apply the SensaTRAC® pad directly over the hole. • Ensure the tubing is connected and both clamps are open. • Press the power button on – adjust therapy settings if	Foam comes in 3 sizes: small, medium and large.

			necessary. • In less than 1 minute of operation, the VAC® dressing should collapse into the wound. • Check the device, the panel will indicate the pressure reached	
CHLORAMPHENICOL 1% EYE OINTMENT	Antimicrobial ointment Must be prescribed on MAR	**Topical application to facial burns, especially over peri-orbital region**	● Frequent application required in order to maintain moist burn wound surface.	
FLAMAZINE CREAM	Antimicrobial cream containing silver sulfadiazine 1% Must be prescribed on MAR	**Topical application to burn wounds.**	● Daily application required	50g tube
SOFT WHITE PARAFFIN	Topical ointment	**Topical application to exposed facial burns**	● Frequent application required in order to maintain moist burn wound surface.	