50 Burns

50.1 Introduction

Burns are common and can vary from minor superficial injuries that you can treat as out-patients to severe life-threatening trauma with extensive deep tissue damage.

The skin is the largest organ in the body. It isolates the inside of the body from the outside, chemically, thermally, mechanically, and biologically. It presents a huge surface protecting against body loss of water, electrolytes, proteins, and heat, and ingress of bacteria and toxins.

There is a very real risk of death in extensive burn injuries, so don't raise expectations beyond what is possible. Full thickness burns covering >50% of the body surface are usually fatal outside specialist burn centres with the necessary resources. However, with the majority of burns, appropriate treatment can significantly improve outcomes and reduce complications.

Most burn injuries are of mixed depth and it is not always easy to assess the depth and surface area involved accurately, especially in the acute situation.

A thorough history and examination is critical and should include details of any comorbidity. Burns accompanying other trauma, such as from a blast or explosion, have a higher mortality; as do burns associated with inhalation injury, especially if there is also chronic airway disease or in old age.

However, with the majority of burns, appropriate treatment can significantly improve outcomes and reduce complications.

Children, because they are still growing are at increased risk of developing contractures (32.1); so, be careful especially to treat children with small deep burns, especially over joints.

Effective management of burns requires a team approach and good nursing care, physiotherapy and psychological support. You can make an enormous difference by getting involved, supervising the management and carefully selecting patients who are most likely to benefit from surgery.

Be ready for surgery in the acute stage: escharotomy & fasciotomy may be needed or early excision and skin grafting (staged if a large surface area involved, but very appropriate for small areas on the hands, feet, neck or face); and then later for release of contractures if they have occurred.

Burn patients often arrive late with contaminated and infected wounds which require intensive treatment. When you see such a patient arrive with little hope in a desperate state, malnourished and with soiled dressings and smelly wounds, *don't just throw up your hands in horror*, but rapidly evaluate their needs, start urgent treatment, and follow the principles we outline.

If you follow these basic rules, and use a safe and simple approach, you will successfully treat many burn patients, so that they are able to continue to contribute to society. Inevitably some will have psycho-social problems which will need further support and long-term follow up. They deserve all the help they can get. Compassionate treatment and a caring team will do much to alleviate the suffering of these young patients and support their journey to recovery.

WHAT SHOULD NOT HAPPEN IN BURNS

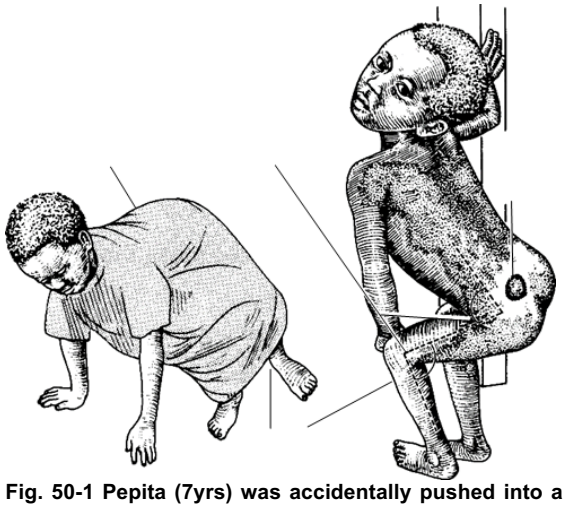


Fig. 50-1 Pepita (7yrs) was accidentally pushed into a fire by another child two years previously and received an 8% TBSA burn of her lower back, which was at first thought to be superficial, but is still open and has never been skin-grafted. She cannot stand upright (A) because of flexion contractures of both hips and one knee. Instead, she has to crawl (B). Her groins were not burnt, and the burn on her knee was only a minor one. Her contractures are the result of failing to make sure that she used her unburnt and minimally burnt limbs during the acute stage of her injury. She has now been abandoned by her family. Early grafting and elementary physiotherapy would have prevented this tragedy.

The focus of this chapter is on the appropriate treatment of less severe burns like this one, so you avoid preventable complications as shown.

50.2 Initial treatment of burns

FIRST AID
The first step is to remove the subject from all potential burning sources including heat flame, electricity or chemicals. The first thing to do is to attend to the personal safety of anyone in the vicinity, especially if a fire can spread or there is risk of explosion.

For flame burns, adopt the rule: *"Stop, Drop and Roll"*. Prevent the victim from running, which only fans the flames and makes them burn faster. As flames always burn upwards, lying flat not only prevents them involving the face, head and scalp hair, but also prevents the fire from going around the body.

Do your utmost to put out the fire by dousing with water; if water is not available, any nonflammable liquid such as milk or canned juice can be used.
N.B. Throwing a blanket over the victim traps the heat and worsens the burn, though may be necessary if he is on fire, to roll him!!

Once the fire is extinguished, remove all the burned clothes (including belts, socks and shoes) from the victim's body.
N.B. Especially with scalds on infants, remove the nappy!

Leave fabric that has melted and is stuck to the burn wound in place. Remove ornaments as they retain heat and continue tissue damage for a prolonged period. Remove rings on fingers and toes before they swell up.

Don't put ointments, creams and lotions over the burn wound before they have been evaluated, as otherwise assessing the depth and extent of the burn wound is difficult, and removal of creams is painful to the patient.

Aspirate or puncture the burn blisters, but leave the epithelium intact as a dressing.

Cool a heat or flame injury with clean running water, the temperature adjusted to the victim's preference for 15–20min. After cooling, keep him warm till medical attention arrives. The 1st 6h following injury are critical; transport the patient with severe burns to a hospital as soon as possible.

If the victim arrives at your health facility without any first aid, drench the burn thoroughly with cool water to prevent further damage and remove all burned clothing.

If the burn area is small and there is no running water, immerse the site in cool water for 20 minutes. This reduces pain, oedema and minimize tissue damage.

If the burn area is large, after it has been doused with cool water, apply clean non-stick wraps around the burned area (or the whole patient) to prevent heat loss and hypothermia. This is a particular risk in children, so remember to keep them warm (even in hot climates!).
If such wraps are not available, use clean cotton sheets.

If the availability of water is limited, soak clean sheets or towels in cool water and keep replacing them on the burn wound to keep it cool.

After you have washed the burn, r*emember to keep the victim warm!*

HISTORY & EXAMINATION

Get a full history as in any case, but concentrate on the events surrounding ithe burn injury. This will help with predicting the burn depth, the risk of inhalation injury and the likely need for admission.

Key factors in the history are:
(1) How was the victim burnt? (what was the mechanism)
(2) When did it occur?
(3) Where did it occur? (*e.g.* indoors, outdoors, at home, work etc)
(4) Was any first aid or other treatment given?
(5) Are there any associated injuries?
(6) Is there any evidence of inhalation injury? (lots of smoke at the scene, coughing, difficulty breathing, burns to face)

Diagnosing a 'serious' or 'major' burn injury is not that simple as it depends on a number of factors. Clearly if someone has a large deep burn, then it is obviously serious, but even fairly small burns, especially if they involve critical areas such as hands, face or perineum are also serious, because they need special care.

Chart the severity of a burn injury (best by a drawing), noting:
(1)Total Burn Surface Area (TBSA)
(2) Depth of burn
(3) Site of burn
(4) Presence of inhalation injury
(5) Associated injury
(6) Co-morbidity

N.B. The degree of injury depends on the heat imparted, the duration of exposure or contact.

Fire or hot metal, plastic, or oil, will generally cause deeper burns than hot water.

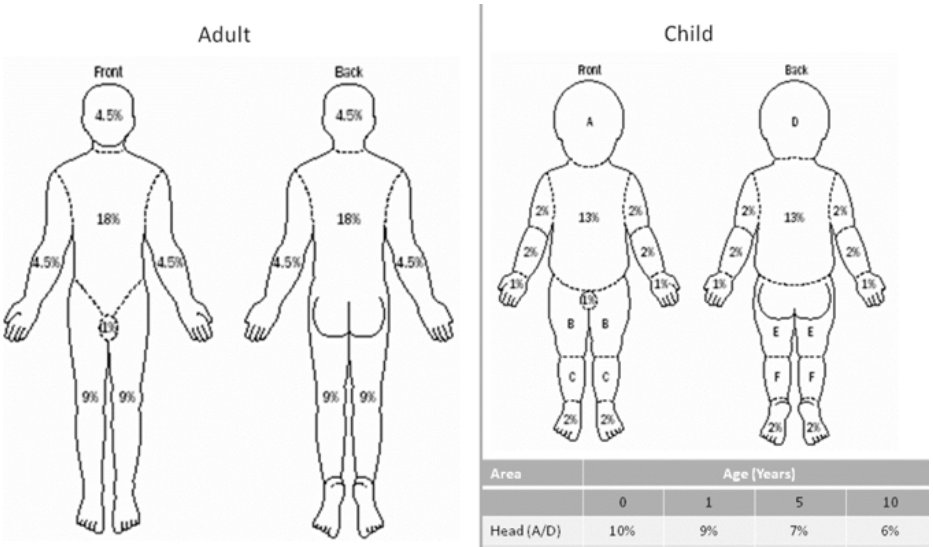
EVALUATING THE SIZE OF A BURN

Measure the size of a burn as a percentage of total body surface area (TBSA). There are several ways of doing this, but it is not always easy. Take care to be as accurate as possible. Describe very small burns in terms of actual size such as 3x5 cm.
For larger burns, a common and simple method is the 'rule of 9's' in adults or '7's' in children.

This is a good way of making a rough estimate of TBSA. Remember 9% is equivalent to the whole arm (back & front), but half a leg (either back or front, or thigh or lower leg). The whole front of the body makes up 2x9% =18%.

The proportions in children vary with age. You can get a more accurate estimate using the Lund & Bowdler chart (50-2). Draw the area of burrn involved onto the chart and then use the chart to predict the TBSA.

ESTIMATING TBSA OF A BURN



Area	Age (Years)			
	0	1	5	10
Head (A/D)	10%	9%	7%	6%
Thigh (B/E)	3%	3%	4%	5%
Leg (C/F)	2%	3%	3%	3%

Fig. 50-2 Calculating TBSA; A, in adults 9% is equivalent to the head, 1 whole arm & hand, the front or back of 1 leg, the chest front, the abdomen, & half the bac, leaving 1% for the perineum. B, in children the head is much bigger compared to the rest of the body. Proportions change with age. *N.B.* the palm & palmar side of the fingers make up 1%. A child's hand is c. $^1/_2$ the size of an adult hand.

As it is rare for the whole of a limb to be affected, especially when multiple areas are involved, it is then easier to use the patient's hand (including fingers adducted) as 1%.

This also works in children; but remember a child's hand is c.50% the size of an adult hand, which is usually a little less than 10x20cm. To simplify estimations, a computerized graphic is useful (50-3); you simply colour in the affected parts, and count the squares & divide by 4.

MODIFIED LUND-BROWDER CHART

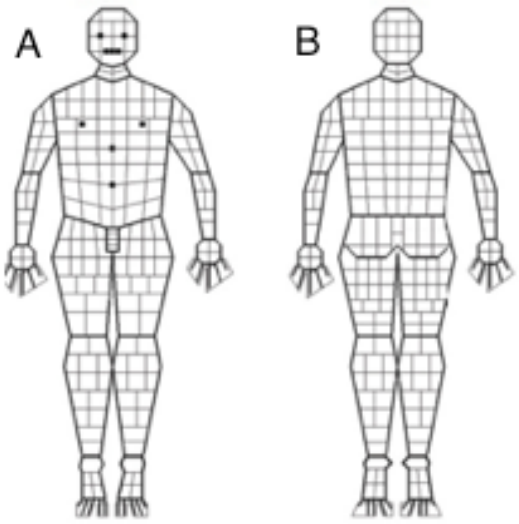


Fig. 50-3 MODIFIED LUND-BROWDER CHART for adults. Colour in affected are as: each square represents $^1/_4$ %, so add up the squares and divide by 4 to get the TBSA. *After Murari A, Indian J Past Surg 2017: 50(2):220-1.*

It is very common to get different TBSA calculations for the same patient. There is no 100% accurate method, but if the estimations differ wildly, re-evaluate the patient, especially in relation to response to fluid therapy.

EVALUATING THE DEPTH OF A BURN

A severe burn is a 3-dimensional rather than a 2-D lesion
Burns are usually classified:

(1) 1st degree (superficial),
(2) 2nd degree (superficial partial thickness),
(3) 2nd degree (mid-partial thickness),
(4) 3rd degree (deep partial thickness),
(5) 4th degree (full thickness dermis).

The depth of burn equates to the liklehood of healing within a certain time frame and therefore the risk of significant scar and contracture formation.

Characteristics Thickness	1st degree	2nd degree superficial partial	2nd degree mid-partial	3rd degree deep partial	4th degree full
Cause	Sun burn	Scalds, flash	Flame contact	Flame contact	Prolonged contact
Depth	Epidermis	Epidermis and part of dermis	Epidermis and dermis	Up to fat & fascia	Charring of muscles, bone or joints
Colour	Erythema only	Pink	Wet, greyish white	Dry, brown, black leathery thrombosed veins present	Dry, brown, black leathery
Blisters	Absent	Present	Absent	Absent	Absent
Capillary return	Present	Present	Absent	Absent	Absent
Pain	Present	Present	Absent	Absent	Absent
Healing	In days without scarring	2wks without scarring	>3wks with hypertrophic scars & contractures	In months with hypertrophic scars & contractures	Will not heal without intervention

1st degree burns have erythema but no blistering; they heal rapidly and represent a minimal injury to the epidermis which rapidly regenerates.

CROSS-SECTION OF SKIN LAYERS

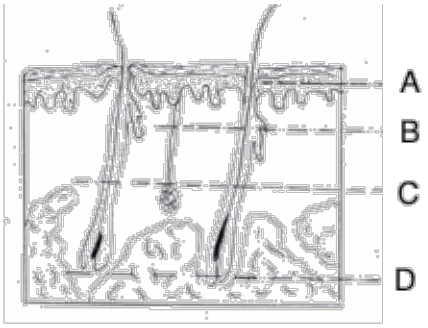


Fig. 50-4 Epidermis & dermis. A, superficial layer. B, superficial partial thickness. C, deep partial thickness. D, full thickness.

Superficial 2nd degree burns form blisters within 24h which rupture to leave a wet pink surface. Most of the deep epidermal structures are still alive, so they heal in<3wks. The pain fibres in the skin are also still intact, so the wounds are very painful and sensitive to the of prick of a needle. Blanching on pressure occurs because capillary return remains intact.
Most flash burns and a lot of scalds are of this type, although scalds often involve all the epidermis and upper dermis. However, there are enough dermal remnants, sweat glands and hair follicles to enable re-epithelialisation with a maximum of 2-3wks and so, the risk of extensive scarring is low.

Deep 2nd degree burns appear greyish white and have all of the epidermis and most of the dermis except for the bottom of the sweat glands destroyed. Therefore re-epithelialisation often takes >6wks (unless the burn is only very small) because the epithelial cells at the bottom of the sweat glands take this long to grow out and cover the dermis. When this re-epithelialization happens, the quality of the skin produced is poor, and prone to recurrent breakdown, hypertrophic scarring & contracture.

Many of the nerves in the dermis are destroyed so they are likely to be insensitive to pin prick, though pressure is still felt. Many of these burns will benefit from skin grafting, to prevent significant scarring and risk of contractures.

3rd degree burns involve the full skin thickness. The dead skin looks greyish brown, and is completely insensitive to pin prick. Thrombosed veins are visible through translucent subcutaneous fat, and hairs are easily pulled out.

The wound can only re-epithelialise from its edges; healing will take weeks to months and definitely result in severe scarring and contracture formation, unless this is prevented by skin-grafting & splinting.

4th degree burns are profoundly deep with fat & muscles charred, and sometimes even the bones & joints.

Burns are dynamic injuries and can worsen because of:
(1) infection,
(2) poor blood supply (*e.g.* as a result of inadequate fluid replacement, cold, septic shock or use of vasoconstrictor drugs, such as adrenaline.
(3) poor nutrition (mainly hypoproteinaemia)

Don't count 1st degree burns (purely erythema) *as part of the TBSA.*
CAUTION! Wounds may deteriorate with time, because of poor perfusion, and so a 1st degree burn may develop into a 2nd degree in a few hrs of injury .

2nd degree burns are relatively easy to diagnose as they are exquisitely painful and moist with blistering. You can treat these with cleaning & dressings. Likewise 4th degree burns are relatively easy to diagnose as they are firm, insensate, and leathery, or even charred. They need excision and skin-gratfing.

The most difficult for diagnosis are the deep 2nd degree burns which may have some sensation and be moist or dry.
These will often require grafting, but not always. If resources are limted, they can be observed and treated with dressings over a few weeks to see if they progress to healing.

You may get an idea of the likely depth of a burn from factors in the history. The hotter and longer the agent, the deeper the burn. Thin skin, such as on the dorsum of the hand, or of a child or elderly person, is likely to suffer greater damage than thick skin.

If someone is drunk, drugged, paralysed, feeble, very old, burnt during an epileptic fit, or unconscious from smoke fumes, he may not have been able to escape from the flames, and so suffers with more extensive burns.

PIN PRICK TEST

This is a test of pin prick (pain, *not pressure*). The patient must be conscious and cooperative, and understand the difference between pain and pressure.

Take a sterile hypodermic needle and practise first on normal skin by asking if he can feel both its sharp or blunt ends. Then test the burn. If he mostly says "sharp", the burn is most likely 2nd degree. If he mostly says "blunt", the test is of less significance, as it might be 3rd or 4th degree

This test is not approapriate in young children.
If the area of burn is relatively small, stretch the skin on either side of the burn area to see if there is blanching of the burnt skin; this indicates a 2nd degree burn.

THE BURN SITE

The site of the burn is important in terms of both the severity, but also the risk of long term disability and functional & aesthetic outcome. Hand burns are critical and if not treated appropriately can lead to significant deformities and impact a person's ability to perform even simple tasks (50-22).

Likewise the face is a critical site; fortunately the blood supply is very good, so 2nd degree burns tend to heal rapidly without any sequelaue; however full thickness burns can be devastating and produce major deformities to the eyelids, mouth and nose particularly.

The dermis on the back is thicker and even deeper burns may heal on the back without significant deformity.

Admit all burns to hands, feet, perineum and face unless small and 2nd degree, as with good care excellent results can be achieved for the majority.

50.3 Inhalation injury

Inhalation injury refers to damage to the respiratory system; this can significantly affect outcome.

There are 3 types of inhalation injury:
(1) Thermal: injury to the upper airway,
(2) Chemical irritation from particles in smoke causing an inflammatory response (bronchopneumonitis),
(3) Hypoxic poisoning from reduction in air FiO_2, Carbon monoxide, or Cyanide.

Recognize inhalation injury by the symptoms and signs, at the primary survey (42.1) Typical are: cough, dyspnoea, hoarse voice, headache, anxiety & confusion.

Signs are facial burns & oedema, singed nasal hairs, blackened sputum, stridor, wheezing & hypoxia.

The history may be helpful; inhalation injury is more common with burns in enclosed spaces and with explosions.

Ask if there was a lot of smoke at the scene, if the victim had to cough or gasp for air, look for singeing around the nose & mouth, and note decreased consciousness or agitation.

If you suspect airway injury, observe the patient over 24h as this is the period when airway problems are likely to develop:

TREATMENT

(1) Sit the patient up – it's easier then to breathe
(2) Administer oxygen, preferably 15l/min, humidified.
(3) Add nebulised salbutamol 2.5-5mg/h for stridor or wheezing.
(4) Encourage deep breathing and coughing to clear sputum, and arrange chest physiotherapy.
(5) Administer rehydration fluids at 1ml/kg/h in adults and 1-2 ml/kg/h in children; but beware: *excess fluid is never helpful.*

If there is a risk of airway obstruction, from swelling: lift the chin & pull out the jaw (42.1) & pass a Guedel or nasal airway if tolerated & available. Administer nebulised adrenaline 5mg as required; *this will not cause cardiac effects.*

If hypoxia persists, intubate and ventilate the victim if you have the facilities; use as big an endotracheal tube as possible to allow efficient suctioning.

Administer 100% O_2 initially until COHb is <5%; humidified. Pressure controlled ventilation is best, and aim for a tidal volume of 6-8ml/kg body weight. Start antibiotics (erythromycin or co-amoxyclav)

N.B. Corticosteroids don't act quickly enough, but are useful if you cannot control wheezing with salbutamol alone.

Start feeding as soon as possible; this reduces the movement of bacteria across the gut wall which provokes pneumonia and sepsis.

50.4 Associated injury

Burns don't always happen in isolation and can be associated with other trauma such as fractures, head injury and other soft tissue injuries. This is particualry true in explosions or a road traffic accident.

Don't focus immediately on the burn wounds, but follow the ABC system (41.2). Shock in early stages is from injury elsewhere.

50.5 Emergency management

INDICATIONS FOR ADMISSION

There are no hard & fast rules who needs admission for burns, but this list will guide you:-
(1) Burns of eyes, perineum or hands
(2) Burns of TBSA >20% in adults
>10% in children
>5% in babies
(3) Deep burns needing debridement
(4) Full thickness burns >5% TBSA
(5) Acid or corrosive substance burns
(6) Smoke inhalation
(7) Burns with other serious injuries
(8) Orther uncontrolled illness (*e.g.* epilepsy)
(9) Unclear history or suspected abuse
(10) Poor support at home
(11) Long distance from hospital to home
(12) Likelihood of poor return for review or poor treatment compliance.

NEED FOR TETANUS PROPHYLAXIS
Any burn patient who has not had a booster within the previous 10yrs should receive tetanus toxoid & tetanus immune globulin (TIG). If this is unavailable, use IV immune globulin.

PROTECTION AGAINST STRESS ULCER & ILEUS
Use a PPI, or cimetidine, or *Gaviscon.* Pass a NG tube for burns >30% TBSA, or when there is a depressed conscious level.

ESCHAROTOMY (GRADE 1.3)

Where there are deep burns, especially if circumferential, they can restrict chest or abdominal movement and lead to respiratory distress, or restrict venous return and lead to a limb compartment syndrome, or neck vein obstruction.

Deeply burnt skin has lost its sensation, and its blood supply, so you can cut it without danger of pain or bleeding. However, it is good to sedate your patient, and when you reach living tissue, there will be pain!

Cut through the escar down to unburnt live tissue, and spread open the wound to release the scar in 2 parallel vertical lines on chest & abdomen, or longitudinal liness on limb surfaces. *Don't hesitate to cross joints, if necessary.*

ESCHAROTOMY

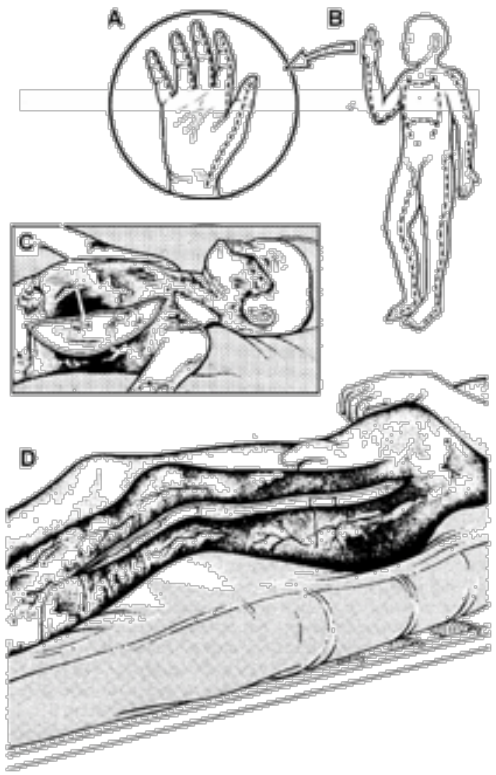


Fig. 50-5 ESCHAROTOMY. A, cut on the dorsum of the hand. B, on the mid-axial lines, lateral & medial, of the limbs (& dorsum of feet); vertical laterally on the chest, with added transverse incisions suprasternally & in the epigastrium. C,D, detail of escharotomies on the chest & thigh. Make multiple cuts if burns are circumferential. *Note visible veins in scarred skin.* *Kindly contributed by Peter Bewes.*

If the patient feels pain when you cut, the burn is not deep, or you are cutting in the wrong place! Escharotomy is the incision of the eschar, and may occasionally need to include the fascia, particularly with electrical burns.

Don't hesitate to perform an escharotomy when there are circumferential or near circumferential deep burns.

Extend your incision (70-5) to normal skin beyond the eschar, or at least from joint above to joint below. *Avoid & spare the veins:* ligate these to ensure haemostasis.

As with all surgical procedures, maintain a clean, if not sterile, operative field. The most frequent complication is bleeding from the subdermal plexus and superficial veins, while the most serious is incomplete release.

N.B. **If you divide eschars late**, there may be extensive septic sloughy tissue below, which may require repeat debridement on several occasions.

Avoid injury to deep structures by staying within the upper subcutaneous fat layer without including the superficial fascia.

An escharotomy is of great value; it might save a life and/or a limb. Always go ahead you are in doubt, particularly in full thickness circumferential burns. Clear important indications are, in a limb:
(1) Painful swelling
(2) Paraesthesia distally
(3) Poor capillary refill distally
(4) Pale cool peripheries
(5) Absent distal pulses *(a late sign)*
(6) Paralysis distally
& in the chest:
(7) Limited chest expansion
(8) Laboured breathing
(9) Hypoxia.

N.B. The presence of distal pulses does not rule out early compartment syndrome, because the pressure required to reduce arteriolar or capillary filling is much less than to occlude blood flow in the larger arteries.

The earliest sign is excruciating pain on passive extension of fingers or toes.

Simple pulse oximetry will help in decision making. A value <90% indicates the need for escharotomy. Likewise compartment pressure (49.8) >40 mmHg is an absolute indication.

However, the decision is usually clinical. Mistakes are usually from:
(1) not performing an escharotomy when needed,
(2) performing escharotomy with inadequate length and/or depth,
(3) extending the incision too deep and damaging underlying nerves or tendons;
(4) performing unnecessary escharotomy in burn skin which will eventually heal without grafting.
(5) overinfusing fluid when burns are limited.
(6) not protecting the kidneys when performing >2 escharotomies.

Structures particularly in danger are the:
(1) Posterior tibial vessels behind the medial malleolus,
(2) Long saphenous vein anterior to it,
(3) Common peroneal nerve winding round the fibular head at the knee,
(4) Ulnar nerve behind the medial epicondyle at the elbow,
(5) Median nerve in the antecubital fossa.

FASCIOTOMY (GRADE 1.3)

Fasciotomy (49.8) is usually indicated for compartment syndrome when this persists following escharotomy. Apart from in high-voltage electrical injuries, fasciotomy is rarely indicated as a primary procedure in burns. When muscular necrosis is evident, fasciotomy has the advantage of direct inspection of muscles to enable early excision of necrotic tissue, thus preventing acute renal failure, infection, and further limb loss.

Complications of fasciotomy occur much more commonly, particularly the injury to neurovascular bundles and deeper structures, than in escharotomy. Fasciotomy, in contrast to escharotomy, is a more technically challenging procedure, and requires GA.

Perform a fasciotomy only when you have firm evidence. First, make an escharotomy alone; if this fails to relieve compartment pressure, *don't hesitate to perform a fasciotomy*.

EMERGENCY DEBRIDEMENT (GRADE 1.3)

If a patient presents late & is toxic and septic from infected burns, with fever, tachycardia & signs of shock (44.5), resuscitate him with large volumes of IV Ringers lactate, start IV antibiotics, and surgically debride the infected wound (50.12). Remove all dead tissue, controlling bleeding either by applying a tourniquet, or using hydrogen peroxide soaks. *Don't attempt to graft the wound at this stage!*

N.B. A temperature on its own of <38^{0}C is not significant but hypothermia is!

CRICOIDOTOMY & TRACHEOSTOMY IN BURNS (GRADE 2.2)

Cricoidotomy or tracheostomy is not often required in the acute situation An overwhelming full thickness burn involving th face, head, or neck, associated with inhalation injury is extremely unlikely to survive. If the airway is compromised due to swelling, and intubation not possible, a tracheostomy can be life saving.

Observe your patient carefully and anticipate the need, before massive swelling of the neck makes a tracheostomy through oedematous tissues a difficult & bloody operation. This procedure is usually only indicated to secure the airway for transfer.

Don't attempt this outside the theatre!
Make a transverse incision. Divide the scarred tissue, carefully securing haemostasis as you proceed, and expose the trachea, then open it (42.3).

50.6 Fluid replacement

Circulatory disturbance in the 1st hour will not be due to the burn, but likely due to haemorrahge (including gastric stress ulceration) or other trauma, or cardiac events. Specifically examine for this (41.1).

If the patient presents many hours, or even days after a major burn, dehydration and shock are usual owing to fluid loss into the tissues and from the burn surface.

Patients with burns >20% TBSA have an increased capillary permeability resulting in massive 'fluid creep' into the interstitial tissues, and decreased intravascular volume, particularly in the 1st 8h after injury. They lose more fluid this way than by evaporation from the surface of the burn wounds or into blisters. However, their total loss of fluid can be immense and can readily cause shock.

Early after a severe burn, patients may look suprisingly well, but without early fluid replacement they risk rapidly becoming shocked. Prevent this and resuscitate them *before they become shocked.*

Burns of >15% TBSA in an adult, or >10% in a child need IV fluid replacement.

Put in as big a cannula as you can *through unburnt skin*, and fix it firmly and start an infusion with Ringer's lactate (or if not available, 0.9% saline).
Avoid using the saphenous vein. An intra-osseous route (44.3) is ideal in children.
N.B. Never use 5% dextrose. *There is no advantage in using colloids early on.*
As you put the cannula in, take blood sample for a haematocrit (or Hb), random blood glucose, serum electrolyte, urea and creatinine (if possible) and for grouping and cross matching for burns >30% TBSA in adults or 20% TBSA in children.

The amount of fluid needed is proportional to the size of the burn and the size of the patient. This amount tails off after 36h. There are several formulae to help you but each is only a guide; you must adjust the volumes to obtain a urine output of 0.3–0.5 ml/kg/h in adults and 1ml/kg/h in children.
N.B. This is the replacement fluid needed. A patient (especially a child) needs maintenance fluids, including a source of glucose.

If you replace fluid loss by mouth*,* use saline or oral rehydration fluid, or milk *but not plain water or tea*. This is especially important with young children. To make a suitable solution, add a teaspoonful of salt, and another one of sodium bicarbonate, to 1L water. If you add fruit juice, and serve the mixture cold from the fridge, no child will refuse it.

INFUSE 3ml/kg/%TBSA IN THE 1st 24h
FROM THE TIME OF INJURY
(NOT THE TIME OF ARRIVAL IN HOSPITAL)
WITH $^1/_2$ OF THIS IN THE 1st 8h.

Calculating the amounts needed, especially if you are stressed, have many patients to see, or it's the middle of the night, is not simple!
N.B. You must avoid the dangers of over- & under-infusion!

It is in children, that calculations are difficult & the risks greatest. Unfortunately, burns affect children mostly! Those critically ill are children with large area burns who arrive late; this is unfortunately often the norm.

As a fluid infusion rate >10ml/kg/h is not advisable in children, this means that a child with 20% burns who arrives 6h after the injury, cannot catch up fluid losses till at least 4h after admission. Thus it is wisest to start at the maximum rate, and slow it down later when you can carefully calculate the requirements.

Overloading children and inhalation burn victims occurs all too easily. In these patients, albumin or FFP infusions are useful, but this needs specialist advice.

If a burn patient presents > 24h after injury, the immediate resuscitation period has passed. He will have a significant fluid deficit. Administer 10ml/kg/h and assess the response by the urine output, which should be >0.5ml/kg/h.

You can normally stop an IV infusion after 48h.

ORAL FLUIDS

Except if a patient is sedated, or has gastritis or ileus, allow as much fluid as tolerated, *but include salt!* Check with the nomogram (41-2) to see how much you should give. In a mass casualty, the ICRC recommendation is to rehydrate patients with up to 40% TBSA with oral fluids at a flat rate of 100ml/kg/24h.

50.7 Monitoring

URINE OUTPUT
Charting urine is the most reliable method to ensure adequate fluid input, but *it needs to be done accurately!*

Don't forget to check for thirst, to insepct the mucous membranes, skin turgor, *pulse, blood pressure, jugular venous pressure, capillary refill and peripheral temperature* as these will all help to evaluate the fluid status.

Remember that you can readily collect a child's urine in a bedpan or urine bottle and measure it 4hrly. This may be more accurate than using a catheter, and measuring the volume every hour.

To do this, use a specially designed urine bag or urine will accumulate and make measurements inaccurate.

N.B. Catheters can become kinked or blocked and give false hourly readings!

Start a fluid balance chart & record *all the input & output.* Keep early urine specimens to compare with later ones. If he develops haemoglobinuria, you will know if this is getting worse or not.

If the urine output drops <0.5 ml/kg/h after the 1st 12h, check if the catheter is blocked.

N.B. Even in acute renal failure, the kidneys can usually manage to produce some drops of urine.

This is a serious sign of kidney failure: if this persists for 2h, challenge an adult with 1l of normal saline in 30mins after checking there are no signs of pulmonary oedema. If this increases the urine output**,** increase the previous infusion.

If an IV challenge fails to increase urine output, administer 15% mannitol (1 g/kg) or 40mg frusemide IV. If this has no effect, renal dialysis may be required.

If a burnt child becomes irritable, vomits, twitches, has fits, becomes apathetic or comatose, suspect that he is hyponatraemic.

Although all these signs are unlikely to occur together, when several are present, cerebral oedema from water intoxication is likely. This may be fatal. Use IV diazepam to control twitching. Correct hyponatraemia by adding:
Na^+ deficit (140–serum [Na^+]) x weight (kg) x0.6.

If you cannot estimate the serum [sodium], assume it is 125 mmol/l, so administer 4.5 x wt (kg) mmol, and repeat this. 3% hypertonic NaCl has 513mmol/l, so use 660ml of this.

FLUID & SODIUM REQUIREMENTS

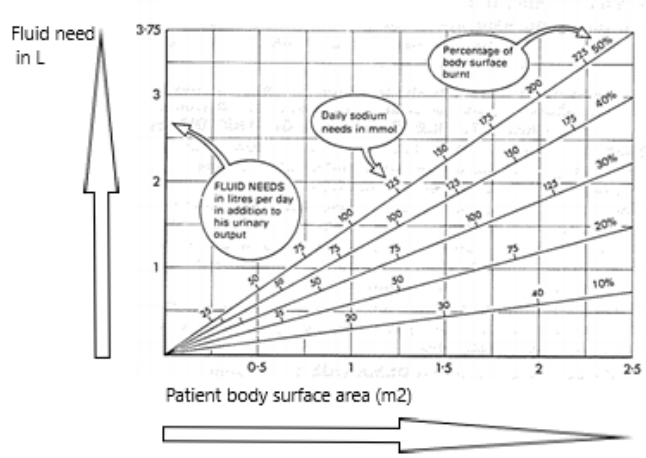


Fig. 50-6 SODIUM NEEDS. Calculate the surface area from 41-2 & read off the daily Na^+ losses (urine loss *not* included) according to % TBSA burnt. Y axis: Fluid need (l) in addition to urine output. X: axis BSA 3% hypertonic NaCl has 513 mmol/l. *Data from Cason.*

BLOOD TRANSFUSION
There is destruction of red cells at the time of burn. A deep burn >10% TBSA in a child, or >20% in an adult, needs some blood, especially if 4th degree. Transfuse after the fluid resuscitation period is over, and repeat it as necessary. A rough guide is to transfuse 1% of his blood volume for each 1% TBSA deep burn. (Check blood volumes from 41-2).

The need for transfusion may increase if there is haematemesis or melaena from gastric ulceration, or other trauma. Further need for blood may arise from depression of the bone marrow as a result of sepsis, and blood loss from desloughing or debriding the wound.

In a malaria endemic area, administer anti-malarial prophylaxis best for that area. Consider prohylaxis for other endemic diseases, such as Leishmaniasis, Leptospirosis, Brucellosis & Filariasis (46.8).

TEMPERATURE
Burn patients readily get cold, as their skin protection is lost, especially if the burn is exposed! Nurse them at 40°C with ideally 40% relative humidity. Monitor the temperature carefully. Feel the extremities.

If necessary, close the windows & put a heater beside the bed. Electric fan heaters are best, but make sure they are kept clean. *Don't put your patient in the sun*, except for short periods, because pink raw skin sun-burns easily.

WEIGHT
Burn patients quickly lose weight unless they have a high protein, high calorie diet.

50.8. Pain relief for burns

There are numerous factors that contribute towards pain and how each individual experiences and reacts to it. Suffering includes what is discomforting or unpleasant for the patient, not just physical pain.

Suffering encompasses anxiety, fear, helplessness, sorrow & guilt.

It is not always possible to prevent all pain, because all burn injuries cause immense physical discomfort. Although a superficial partial thickness burn is much more painful to the touch than a full thickness burn, an extensive full thickness burn gives rise to severe distress.

You must anticipate anything that might contribute to or precipitate pain, such as dressing changes or any operation, or physiotherapy exercises.

Don't think if you don't have potent analgesics such as morphine, there is nothing you can do! By using varied medications, different modes of administration, and combining drugs, you can achieve much (37.1)

Look at what you do have and see if you can use any of these medications. Changing the route of administration, the dosage or the frequency may all be useful.

50.9 Burn wound care

WOUND CLEANSING

Gentle washing is the most important component of burn wound cleansing. Do this with water that is safe to drink; *it does not need to be sterile*. This is the first step in infection prevention and cure, and essential for sound healing, and patient satisfaction.

The main objectives are to remove:
(1) contaminants at the wound base,
(2) debris,
(3) foreign bodies,
(4) microorganisms in infected wounds,
(5) superficial slough,
(6) dressing materials,
(7) excess exudate & crusts
(8) hyperkeratotic skin from wound edges & surrounding skin.

However, most importantly, by this you aid the patient with personal hygiene and comfort.

Irrigation is significantly more satisfactory than swabbing to patients.

During the first 3-4h after a burn, wounds are generally sterile or are at the stage of superficial bacterial colonization. By the 4th or 5th day, extensive bacterial involvement of the wound itself appears. By 7days, the damaged skin is thoroughly permeated by a large number of organisms and those more virulent begin active invasion of the unburned tissue. Because blood vessels in the burnt skin are damaged, antibodies & antibiotics cannot reach them.

Gently clean early wounds to avoid injury to the lower layers of the epidermis, responsible for regeneration and healing.

However, for heavily contaminated or infected wounds, aggressive, thorough, and frequent cleansing is necessary to eliminate the biofilm.

If the biofilm is not responding to irrigation, debridement (surgical cleansing) is needed to break the vicious cycle of biofilm-induced infection. Only remove dead tissue and tight debris.

Then re-start irrigation for another few days and reassess the situation for possible further debridement.
In heavily infected wounds with an evident biofilm, use topical antimicrobials after irrigation to combat the exposed bacteria and organisms that became accessible after cleansing. Similarly, use these after debridement, as they block virulent organisms getting into the spaces opened up by surgical intervention

BLISTERS

Blistering occurs in 2nd degree burns; there are no hard and fast rules about leaving them or puncturing them. It's best to leave small blisters. De-roof large blisters as they are uncomfortable and prohibit mobilisation (especially on the hands); alternatively aspiratie them using a sterile technique. However, de-roofing eases wound inspection and management.
N.B. Remember the de-roofed surface is very sensitive!

2nd DEGREE BURNS
These will heal within 2-3wks and the key to succesful management is avoiding wound infection and preventing the wound drying out.
You can acheive this best by closed dressings whenever possible.

CLOSED BURN WOUND CARE

Make sure your patient gets adequate analgesia (GA may be needed); take a pus swab, and then clean the wound thoroughly with an antibacterial wash such as aqueous *(not alcoholic)* betadine or chlorhexidine, using a sterile 'no touch' technique.

Apply a liberal layer of a topical antimicrobial ointment such as silver sulphadiazine followed by 2 layers of paraffin gauze (to prevent the dressing sticking to the wound, making it painful to remove), extending 10cm beyond the burn wound. Follow this with a layer of gauze, & a firm (*but not tight*) crepe bandage to prevent oedema. Cover this with a loose layer of wool to act as an absorbent layer, followed by a further layer of crepe. The whole dressing should be at least 2cm thick.

If the wound soaks through the dressing, remove this outer layer of wool and crepe, leaving the inner layer intact for up to 5 days depending on the state of the wound.

Advise the patient not to get the dressing wet or dirty and review the patient regularly until complete healing.

If the wound is small (<5%TBSA) and there is no soiling of the dressing, leave it for 5days on the hands, 7days on the arms, 10days on the legs.

However larger areas often produce quite a lot of exudate in the first few days and may need daily or alternate day dressings initially.

Advise the patient to look out for signs of infection such as a foul discharge, increasing pain, tachycardia and a temperature and come for review straight away.

Closed methods enable early mobilisation. This is beneficial form a psychological point of view, but only if you change the dressings regularly, inspect the wounds. *Never condemn a patient to days with soiled and smelly dressings gradually unravelling*!

So, the primary goals are preventing viable tissue from drying up and controlling the bacteria. If the wound dries out, a scab forms and delays epithelialisation.

DRESSING A BURN WOUND

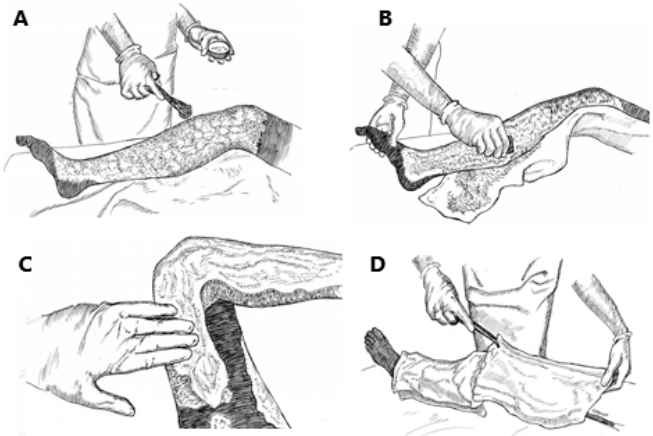


Fig. 50-7 DRESSING A BURN WOUND. A, use a 'no touch technique'. Use sterile forceps & sterile gloves so that no human hand or unsterile instrument touches the burn or the dressings, and no sterile glove touches anything else in the room. Clean the wound and the skin around it with chlorhexidine solution. *There is no need to puncture any blisters.* B, remove any necrotic tissues C, using a sterile spatula, spread an antiseptic agent (such as silver sulphadiazine) onto the wound. D, cover the cream with sterile gauze & then by firm bandage.

The closed method: (1) Demands more and better nursing care than the exposure method. (2) Needs abundant dressings. (3) Is more dependant on a local antiseptic agent than the exposure method. (5) Can cause hyperpyrexia in large burns in hot environments.

Done *well,* the closed method can be wonderfully successful. When you remove a dressing from a partial thickness burn which you have left undisturbed for 10days, you may find perfect new skin underneath.
But this method can be very dangerous if you forget that dressing a burn is a surgical procedure, which must be done aseptically, and the aim of the dressings is to contain exudates, and prevent organisms reaching the burn.

This means that you must change them on the indications given below.

Done badly, this method is a disaster, and too easily converts a partial thickness burn into a full thickness one.

Common errors are: (1) Not applying enough dressings (sometimes only a thin layer of gauze). (2) Letting exudates soak through without changing the dressings. (3) Not bringing the dressing well beyond the edges of the wound. Then this technique is painful, messy, expensive, and hinders healing.

There should be no compromise; either a burn should be left open with nothing on it at all, or it requires 2cm of dressings. *If therefore you use the closed method, you must do it properly!*

Under most circumstances, it is only suitable for parts of the body where the necessary dressings will stay in place. In effect, this means the limbs. In practice, because of the cost of the dressings and the labour involved, you will find the closed method suitable for burns on the limbs. It becomes increasingly difficult with larger burns, and on the trunk.

THE MERE APPLICATION OF A FEW 'DRESSINGS' IS *NOT* THE CLOSED METHOD

EXPOSURE METHOD

This is useful for for parts of the body which cannot easily be dressed, such as the face, hands, trunk, buttocks, and perineum. The patient should be under a mosquito net.

In this method nothing touches the burn wound except air, and an antibacterial agent, such as silver sulphadiazine. Air keeps the wound cool and encourages a dry eschar to form, both of which minimize the growth of bacteria.
You can examine the wounds easily and it avoids expensive dressings; but outside of special units, the risk of infection is great, and the likelihood of neglect increases.

In 2nd degree burns, the crust eventually separates like the skin of a snake to leave new, pink, well healed skin underneath; however, if the wound dries out too much, the wound will deepen and delay healing..

In deeper burns, the dead tissue forms a tough eschar (sometimes with pools of pus underneath it), or less often forms a moist slough. It is best to cover these then with saline soaks, or continuous irrigation, till you can remove them easily & skin-graft the surface.

If the exposed burns itch & are scratched, try to prevent the patient from doing so, because scratching can easily infect or convert a superficial burn into a deep one. Immobilize both the elbows in padded plaster cylinders to keep them extended. Add sedation. *Don't tie the hands to the sides of the cot*, because this is cruel and dangerous.

CONTINUOUS IRRIGATION

Use 1/2 strength saline (0.9% saline is painful.) Either place the burnt part in a basin or bath, or pour or drip it over the wound, and catch excess in a bucket .

If you see green discharge staining the dressings, use vinegar (0.5% acetic acid) instead of saline for a few days, as it is *very* effective against pseudomonas.

ALTERNATIVE DRESSINGS

Amniotic membrane; whether iused fresh, lyophilized or irradiated, is useful on heavily infected or exudating wounds.

Its main risk, if fresh, is the transmission of HIV, hepatitis and other serious diseases, so despite it being readily available in large amounts, you must have a proper set up in place to use it, rather than just once off.

SLOUGHS AND ESCHARS

Dead tissue from a burn wound separates off with time. If the burn is superficial, it peels off as pieces of a dry membrane. If it is deep, it forms either a slough, which is moist, soft, grey, and stinking, or an eschar which is dry, hard, and dark, which may be so brittle that it cracks.

There is no sharp distinction between slough & eschar; at the wet end is a slough, at the dry end an eschar. So irrigation tends to produce a sloughy wound, and exposure an eschar.

Occasionally, an eschar may protect underlying tissues from infection for several weeks (particularly if only skin is burnt), but a thick, tough, dry eschar can act like a tourniquet, and constrict the neck, chest, limbs or fingers.

The underlying oedematous tissue swells, but as the eschar around it is rigid and cannot expand, the circulation becomes impaired. Escharotomy (50-5) may therefore be needed as an emergency.

Underneath slough & eschar is a wet surface needing skin grafting. Maggots can deslough dead tissue effectively, although their use is not, naturally, very popular!

TOPICAL ANTIBIOTICS HAVE *NO PLACE* IN BURNS DRESSINGS

If muscle is dead, infection occurs much more readily, and a rise in temperature about the 10th day is usually the sign. You cannot often see Infection under an eschar, but pain is a significant symptom. When infection is advanced, you may be able to feel a dry eschar floating on a pool of pus.

If there is much dead muscle, beware of anaerobic infection, particularly gas gangrene and tetanus, and proceed to early surgical desloughing.

DESLOUGHING

Manipulating any infected tissue may cause bacteraemia, and removing an extensive slough or eschar may shower so many bacteria into the circulation that it causes septic shock (53.4). So, if you deslough a severely infected burn, administer broad spectrum antibiotics beforehand.

Slough not badly infected does not need antibiotic treatment; that is why regular pus swabs are useful.

Sloughs and particularly eschars may bleed massively when you try to remove them, especially if they are large. So, do so a little at a time in stages, separated by a day or two. Remove them gently, and watch out for heavy bleeding and stop.

Hydrogen peroxide is useful to control bleeding, as well as firm pressure for 5mins by the clock. *Never deslough >10% BSA at one time!*

The ideal is to skin-graft the raw area after you have removed a slough, but the granulations on the surface should be smooth with small undulations (50.13).

Continuous suction (negative pressure) dressings (11-20) are particularly useful if wounds are infected, boggy and wet.

A nurse may carry out a minor sloughectomy in a dressing change, but anything more major is best done in theatre.

Desloughing can vary from a minor procedure, if a burn is small, to an extensive 'sloughectomy' in the theatre, particularly if large and deep.

One of the commonest mistakes is not to deslough a burn; as long as any slough or dead tendon or bone remains, a graft will fail.

DESLOUGHING

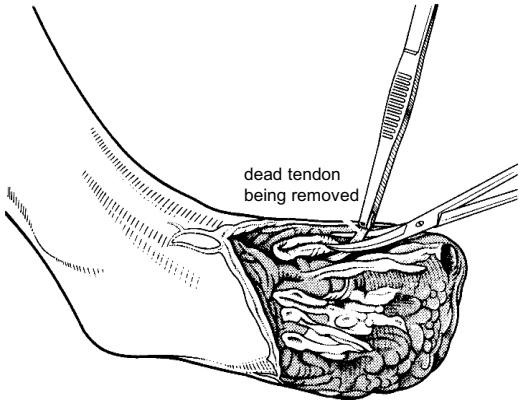


Fig. 50-8 DESLOUGHING Eda's tendons and some of the metatarsals have sloughed, which are being removed. She went home walking.

IF YOU TRANSPORT A BURN PATIENT, KEEP HIS WOUNDS MOIST

50.10. Nutrition in burns

All burn victims have an increased requirement for calories, owing to the healing response. Children are growing and therefore require relatively more energy than adults.

In burns, there is a marked inflammatory response. This leads to a high basal metabolic rate, protein breakdown, muscle wasting, & deficiencies in vitamins and minerals.

Early feeding (starting when the patient is admitted) can prevent gut ulceration, which can lead to bleeding, & bacterial translocation, where gut bacteria pass across the gut mucosa into the blood stream, causing septicaemia.

Adequate nutrition allows optimal healing, & a satisfactory result for the care team and patient. Convalescence is reduced and the victim can resume normal activities, and get back to work or school much quicker.

Inadequate nutrition results in significant complications and increased mortality from;
(1) Weight loss
(2) Muscle breakdown
(3) Generalised weakness & anaemia
(4) Apathy
(5) Delayed wound healing & chronic wounds

Protein loss leads to oedema (which can lead to joint stiffness), muscle weakness & Immune suppression, so increases the risk of infection.

If a victim loses 10% from his pre-morbid weight, he is likely to develop complications. *A 40% weight loss is generally fatal.*

A severely burnt patient may develop gastritis or paralytic ileus. This may result in nausea, vomiting, haematemesis, gastric ulceration, or abdominal distension & intestinal stasis.

Avoid these problems by administering antacid, H_2-blocker or PPI, & pass a nasogastric tube, aspirating on this hrly. You need to replace these extra fluid, sodium & potassium losses.

N.B. Exclude other causes of GI upset such as septicaemia, malaria & simple constipation.

Anaemia may result from:
(1) red cell destruction at the time of burn,
(2) bone marrow depression from sepsis,
(3) a lower lifespan of red blood cells,
(4) blood loss from over-zealous debridement.

Many patients are anaemic even before their burn; a child may easily drop his Hb level to <50g/l 7days after burn injury. As transfused red cells are relatievely inefficient, *don't hesitate to transfuse early*.

HIGH PROTEIN HIGH CALORIE DIETS

You may not be abe to calculate the amount of calories and protein a patient is getting. The principle remains to give locally available high calorie high protein foods frequently.

Requirements are:

	Energy (kcal)	**Protein**
Children	60/kg+35/%TBSA	3g/kg+1g/%TBSA
Adults	20/kg+70/%TBSA	1g/kg+3g/%TBSA

N.B. 1 kcal ≅ 4kJ.

Poor patients often need oral supplementation of vitamins.
Keep to an approximate ratio of carbohydrate: protein: fat at 50:30:20% in the daily requirement.

Monitoring the weight of the patient on a regular basis is very important; remember to try to find out a child's weight before the burn injury; check the weight on arrival, and then *daily for 2wks.* Also measure children's mid-upper arm circumference

N.B. Danger alert is a loss ≥10% of the pre-morbid body weight.

N.B. Fluids administered & oedema may give you a falsely high weight reading.
Generally stick to these rules:
(1) Give extra food high in calories and protein
(2) Use locally available foods
(3) Be sensitive regarding vegetarian or meat diets.
(4) Choose an oral or nasogastric route (or both): 8Ch for children, 14Ch for adults
(5) Give small frequent feeds rather than infrequent large ones
(6) Start feeding straight away
(7) Give extra feeds between standard "meal times"
(8) Encourage the patient's family to help
(9) Supplement with vitamins A, B,& D, 600 mg ascorbic acid, + 600 mg ferrous sulphate daily.
(10) Weigh patients every 2nd day.
(11) Supplement feeds *(& fluids)* in case of diarrhoea

Approximate protein/energy contents of simple foods are:

100g	**Protein (g)**	**kcal (=Calorie)**
Milk powder	150	500
Cow's milk	8	60
Soya beans	50	350
Beans	15	260
Peas	5	90
Groundnuts	25	560
Beef	25	150
Liver	20	190
Maize meal	7	370
Eggs	12	160
Margarine	0	700
Oil	0	900

A butter milk diet is good option; it consists of 4 eggs, 4 bananas, teaspoons sugar, 1l curd & 600ml water; you can add 50g ghee (clarified butter): this gives 1 kcal/mL.

NASOGASTRIC FEEDING

CAUTION! **If you use a NG tube for feeding**, make sure that the tube is in the stomach, *and not in the trachea,* (4.9). *Always aspirate the stomach before giving a feed*, to make sure that it is emptying properly. *In an unconscious patient, overdistension may cause regurgitation and aspiration of feed.*

If the patient has previously not been eating, start with $^1/_2$ or $^1/_4$ strength feeds initially, until you are sure that he has adapted adequately to this new method of feeding.

Use small blenderized feeds to start with, well spaced throughout the day and night. Filter them through gauze and make sure you give water at the end of every feed to prevent them clogging the tube .

ALWAYS LABEL THE FEEDING LINE *&*
NEVER CONNECT IT TO AN IV CANNULA !

If the feed blocks the tubing, administer it intermittently with a large syringe, but *beware of pushing large quantities into the stomach!* If you aspirate 100ml, wait before re-introducing another 100ml.

Work up to the required intake over several days. 3,5kcal and 180g of protein are about as much as an adult can take.

Always add enough water (about 30 ml/kg) in addition to the non-renal losses to help digest the food.

Make sure you provide at least 10% of the energy needs as fat.

Urinary potassium losses may be large. As a rough guide, administer 100mmol/day by mouth.

DIFFICULTIES WITH TUBE FEEDING

If you don't have a blender, mix milk, eggs, sugar, vegetable oil, and gruel of various kinds.

If diarrhea ensues, the feed may be hypertonic. Try diluting it.

If the feed regurgitates you have probably failed to check that the stomach was emptying poroperly before adding more feed. So, check the gastric residue, and raise the head end of the bed.

CAUTION! A blenderized feed is readily infected, so boil it and keep it refrigerated. *Don't add salt or you will overload your patient with sodium.*

Nursing Care

Use this nurses‘ wound care checklist:

1.Inform the patient about today's wound care
2. Assess the patient's general condition
3. Record the patient’s vital signs
4. Decide where & when you will change the dressings
5. Make sure of adequate analgesia
6. Prepare all the materials for dressing change
7. Assess the condition of the old dressings
8. Assess the wound (depth, size, infection)
9. Note any changes from the previous dressing change
10. If infected, take a wound swab
11. Decide if you need to change the treatment
12. Assess the range of joint movement around the burns
13. Decide if you need to inform the doctor
14. Check if there are any pressure sores
15. Check if there are any new wounds
16. Reapply the splints
17. Check if the new dressings allow sufficient movement
18. Document 1-16
19. Inform the family of progress
20. Ask if the patient has any questions or concerns

50.11 Physiotherapy in burns

The majority of the care for burns patients is delivered by nurses including dressing changes, general hygiene, infection prevention and control, nutritional support and psycho-social support. Physiotherapy is often not available and if this is the case, correct positionoing and encouraging mobilization must be carried out also by the nursing staff.

There are many things which make it difficult for burn victims to move. These include fear, pain from wounds, bandages, scarring, being systemically unwell and lack of education. However, if they do not mobilise, they will become stiff, develop contractures, have a longer in-patient stay and find it harder to regain their place in society.

Anti-contracture positioning must start from the 1st day (and should continue for many months after injury). It applies to all patients before or after skin-grafting. Scarring reduces tissue length, and range of movement (ROM).

Patients will naturally rest in a position of comfort, which is usually the position of flexion; this leads to contractures which can severely restrict movement. The results are catastrophic, with disfigurement and muscle loss.

Correct positioning, splinting and exercising results in less scarring, better function, decreased pain, increased muscle power, and makes management easier for patients and relatives. This leads to earlier discharge, earlier return to work and an improved economic and social future.

Patients need to adhere to a positioning regimen in the early stages of healing and this takes teamwork and dedication. They require ongoing advice and help with positioning, from all members of the healthcare team and their family. Encourage them to maintain anti-contracture positions all the time (except for when carrying out exercise programmes and functional activities), not just whilst a therapist is on hand. Early compliance is essential to ensure the best possible long term outcome and also to ease pain and assist with exercise regimens. Educating the patient and family so they have a good understanding as to the benefits of participating in therapy is essential; getting the family on board at this early stage also helps them to be more prepared to assist the patient on his return home.

You can achieve correct positioning in a number of ways; this sometimes involves the use of splints.

It is crucial not to overlook patients who have relatively small burns as they may also develop serious and debilitating contractures which could be easily avoided. These patients comprise the largest proportion of patient numbers and may be only attending hospital as out-patients. Look at positions to avoid contractures (50-9A-J).

SPLINTING

Splints hold a joint (or body part) in a rigid position: *you must make this the 'anti-deformity' position*.

Splints are particularly needed when a patient is not exercising, and whilst adopting a position of comfort, *e.g.* at night when asleep. So, get patients mobilising at every opportunity but use splints whilst at rest.

Splints may have to be continued for 6months after the burn injury, in order to prevent late contractures. *You can always find and provide some form of splint.* Splint materials are everywhere around; it is just a matter of looking!

The principles of rehabilitation programmes are:
(1) Minimise swelling & oedema
(2) Prevent Deformity
(3) Mobilise
(4) Maintain function
(5) Treat long term scarring problems

PREVENTING CONTRACTURES

The great danger of a scar is that as it contracts it will pull a joint into an abnormal position. Also, as a child grows, the scar does not. Most contractures result on the flexor surfaces but also on the extensor surfaces of the wrist, hand, & fingers.

You can minimize all contractures and prevent many of them completely by using quite simple methods. *Failure to apply these methods is one of the commonest mistakes in treating burns.*

These are your priorities:

(1) Correct positioning, maintained by splinting as necessary
(2) Early activity to prevent stiffness (full active & passive ranges of movement)
(3) Elevation to prevent oedema
(4) Good analgesia to enable mobilization
(5) Good nutrition to support wound healing
(6) Preventing infection converting partial to full thickness skin loss
(7) Get early skin cover, especially over joints
(8) Use sheets, rather than patch grafts or mesh over joints if possible, but make sure you 'fenetstrate' them (make small holes with a scalpel to allow fluid and blood to drain out.

N.B. Stiffness is seldom serious until you immobilize a joint for 3wks in an adult or 6wks in a child.

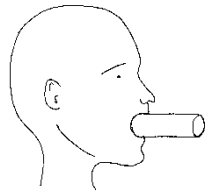
So splint a joint continously ≤3wks in an adult & ≤6wks in a child, while the skin over it heals.

After this, you must mobilize the joint; only splint it then at night. You are battling against time to get the skin to heal: that is why grafting early is so important!

Contractures may continue to form for >12months, so continue the appropriate night splinting as an out-patient, and review regularly. Contractures form less quickly later, but early on, they can form in a few days.

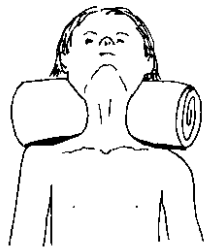
(a) Face
AVOID MOUTH & EYE CLOSURE
(1) Facial stretching exercises
(2) Well-padded splint in the mouth
(3) Tarsorrhaphy (28-13)

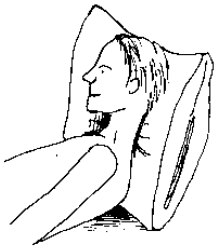
A



(b) Anterior neck. **(c) Posterior neck**
AVOID NECK FLEXION & NECK EXTENSION
(1) Roll behind the neck (1) Pillow behind head
(2) Neck collar with
chin lift

B **C**

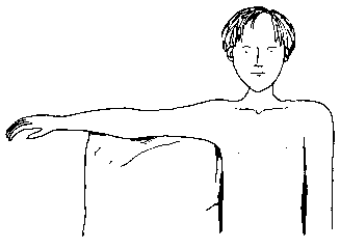




(d) Axilla
AVOID SHOULDER ADDUCTION
(1) Lying and sitting with arms abducted to 90° supported by pillows or angled splint between the chest & arms. Figure of 8 bandaging or strapping.

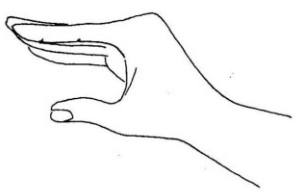
(e) Elbow
AVOID ELBOW FLEXION
(1) Splinting elbow in extension

D,E



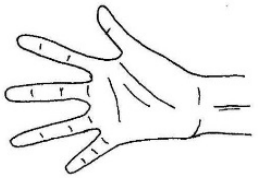
(f) Wrist & back of hand
AVOID WRIST FLEXION;
MCP HYPEREXTENSION;
IP FLEXION; & THUMB ADDUCTION
(1) Extend wrist 30-40^0
(2) Extend mcp joints 60-70^0
(3) Extend ip joints
(4) Abduct radius in mid-palmar position

F

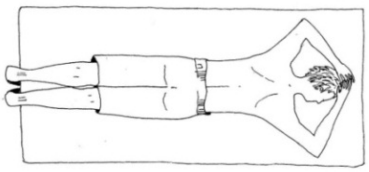


(g) Palm
AVOID FINGER FLEXION & ADDUCTION;
& CUPPING OF PALM
(1) Hyper-extend wrist
(2) Minimally flex MCP joints
(3) Extend & abduct fingers

G

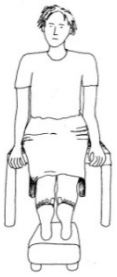


(h) Groin
AVOID HIP FLEXION & ADDUCTION
(1) Lying with leg extended
(2) Limit sitting and lying on the side
(3) Traction on lower leg



H

(i) Knee
AVOID KNEE FLEXION
(1) Leg extended when lying & sitting



I

(j) Ankle
AVOID DEFORMITY
(1) Keep ankles at 90^0 using pillow or splint
(2) Sitting with feet flat on the floor
(if no oedema)
N.B. You may need to keep a serious dorsal ankle burn plantigrade initially (71-10)

J

Fig. 50-9 POSITIONS TO AVOID CONTRACTURES. A, mouth. B, anterior neck. C, posterior neck. D,E axilla & elbow. F, wrist & hand. G, palm. H, groin. I, knee. J, ankle.

Therefore, try hard to educate a mother of a child what a night splint is for, and why she *must* apply it. It is very sad to see a contracture recur, which you have carefully released, because the night splint was not used!
Train a physiotherapist, and also the family to be home physiotherapists!
You can reduce the risk of hypertrophic scars by applying a specially made pressure garment. A child should then wear this for several years.

N.B. Remember that if a patient lies continually in the same position because of a burn elsewhere, contractures will form in the unburnt limbs!

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RULES FOR MANAGEMENT

(a) Reduce oedema
(1) Sit up the patient
(2) Elevate limbs (feet above heart level)
(3) Elevate the head (raise the head end 20^{o})
(4) Firm dressings, mobile at joints (50.9)
(5) Active mobilization
(6) Good nutrition (50.10)

(b) Prevent deformity
(1) Correct positioning
(2) Splinting at rest & night
(3) Exercises (passive & active) early on
(4) Encourage stretching
(5) Encourage activity

(c) Mobilize
(1) Exercise (Improve exercise tolerance and muscle strength); possibly 5days after skin grafting.
(2) Play therapy for children

(d) Maintain function
(1) Educate patients and family
(2) Encourage functional tasks
(3) Encourage independence; adapting to the environment where necessary
(4) Control pain and suffering
(5) Encourage social interaction & re-integration into the community

(e) Reduce long term scarring
(1) Compression therapy
(2) Splinting
(3) Moisturise wound with cream or oil
(4) Massage
(5) Stretching
(6) Muscle exercises
(7) Avoid secondary trauma to the scar

50.12 Surgical care of burns

Surgery is critical if you want to get the best results for burn patients and avoid many of the long term complications that happen when wounds are left to heal spontaneously.
Debridement and skin-grafting are essential for the optimal treatment of patients with a significant %TBSA of deep burns.

EARLY EXCISION & GRAFTING
Done between 3-5days after the burn, this reduces the incidence and severity of contractures, improves long-term outcome, reduces hospital stay and is cost effective.

Nonetheless, you need a properly set up dedicated team to manage this properly. Apart from a real sterile theatre environment, skin grafting equipment (Watson or Humby knife, dermatomes, electrocautery, tourniquets, skin graft mesher), you need good microbiology & blood transfusion.

If you don't have these, your efforts may endanger patients and give poor results, which will harm your burn service because of damage to morale and reputation.

So, don't try this for:
(1) partial thickness (2nd degree) burns
(2) >20% TBSA burns

The main indications are small deep burns, especially of the hands (back & palm). Remember though, that excision on the fingers must be delicate and takes time.

Don't excise >10%TBSA at any one time! You can anyway not cover >30-40% TBSA with skin from the same patient. Waiting for skin donor sites to heal, so you can harvest skin from the same site as before, takes at least 10-15 days. Also, debriding >20% TBSA will cause much haemorrhage which will require blood transfusion.

The face has a very good blood supply, *so don't excise facial burns unless very obviously full thickness and small.*

After early surgical excision of the burn, the surface is likely to be optimal in cleanliness, so you must cover all excised burn wounds with a skin graft.

If there is a very obvious purulent infection, clean the wound thoroughly, use dressings and antibiotics, and try grafting after 48h.

DELAYED SKIN GRAFTING
on granulation tissue after delayed primary burn excision, spontaneous sloughing or active desloughing of the burn wound, happens after 10-21days.

So decide whether to excise burn wounds early or late, and whether this excision is tangential or fascial.

In the tangential method you take repeated thin slices of necrotic tissue (burn eschar) till you reach viable tissue). In the fascial method, you remove the burn wound and subcutaneous tissue to a pre-determined deep level, typically down to deep fascia.

The routine practice of early excision and grafting of full thickness burns can reduce both direct & indirect medical costs. This is particularly true of smaller burns, on functionally important areas such as the face, hands and feet. So, reduction of scarring and subsequent immobility, by early excision and grafting will have an enormous impact on reduction of disability.

You will see the economic benefit not only for your patients, but also your hospital!

If, however, in your set-up, you have:
(1) concerns regarding infection,
(2) patients presenting late,
(3) large burn wounds which will bleed,
(4) limited experience,
(5) very basic equipment,
you will probably prefer the conservative management of deep burns by desloughing. By waiting until sloughing of the eschar has occurred, surgery is kept to a minimal scale, with harvest of the skin grafts being the main surgical intervention.

If you use this conservative approach, it is crucial for your burn team to emphasize a rigorous approach to dressings and wound care, develop pain management protocols, optimize patients' nutritional intake, and work assiduously to prevent contractures by means of physiotherapy and splinting.

If you leave a deep burn wound, it is at high risk of becoming infected, which can lead to generalised sepsis and death.

So, remove as much full thickness burnt skin as possible, as early as possible.

DEBRIDEMENT (GRADE 1.3)
Remove any dead or infected tissue using scissors if there are large sloughs that normally seperate well.

If there is no obvious slough, use a Humby or Watson knife (50-10) to shave the dead tissue away until healthy tissue is reached underneath. Take quite thin tangential layers even if this means repeating cuts 5-6 times till you get to healthy tissue. When you are more experienced, you can use fewer, deeper shaves.

N.B. Non-viable tissue is usually thick and leathery with no bleeding and thrombosed vessels. It can also appear white or dark red depending on how old the burn is.
Viable tissue has punctate bleeding, bright yellow fat and no thrombosed vessels.
This tissue will take a skin graft.

Although a tourniquet will prevent the area being covered by a constant ooze of blood, you need to be careful to make sure you don't cut too deeply. Use tangential shaves till you get to punctate bleeding. When you have excised all the dead tissue, wrap the limb in adrenaline soaked gauze and apply a further layer of dry gauze then a tight elastic banfdage.

Elevate the limb and then let the tourniquet down and maintain elevation for 3-5 minutes. The slowly unwrap the elastic dressing and soak the gauze off starting distally whislt still maintaing the limb elevated. Do not rub the excised area as this will just restart the bleeding. Any obvious bleeding can be stopped with cautery.

If there are extensive deep burns, remove all the subcutaneous layer right down to fascia. It is easier to control the bleeding, but takes longer and does not give a good aesthetic result, but can be life saving. You can apply a skin graft directly to the fascia.

50.13 Skin grafting

DIFFERENT KINDS OF WOUND COVER

If the whole skin thickness of the skin is lost, natural healing will cause the epidermis to grow slowly inwards from its edges. If the wound is <2cm across, this works well.

But if the wound is larger, healing will take a long time with contracture, or disability if nerves & tendons are exposed. Tropical ulcers (34.9) also often need cover.

So, if you cannot bring the skin edges of a wound together by direct suture, or advancement flap (34-12, 46.5), you have 3 choices:

(1) You can slice the superficial layer of skin (a split skin graft) from another part of the body (the donor area) and lay this on his wound (the recipient site). It can survive, because the whole epidermis can regenerate from the deeper parts of the skin layers.

(2) You can take the whole thickness of some skin from another part of the body (a full thickness graft) and suture this into the wound. It may survive but can only be small (<2cm^2) & needs a good blood supply. If you use many small full thickness 'pinch' grafts, you can cover quite a large area.

Both split & full thickness skin grafts are completely deprived of their former blood supply. They initially survive from nutrients in inflammatory exudate, and then on tiny vessels that grow from the wound surface into the new skin.

(3) You can move the whole thickness complete with its blood supply, and suture it in place over the wound (a flaps or pedicle grafts). This requires some experience (46.5) and depends on how long and wide the flap can reach.

SPLIT SKIN GRAFTS
are the most useful kind of graft because they:
(1) can cover large areas of the body.
(2) take (*i.e.* survive) well.
(3) are easy to cut.
(4) resist infection moderately well, so you can put them on granulations which are not completely sterile.

Disadvantages are that they:
(1) are fragile
(2) *don't match undamaged skin well*
(3) *don't resist trauma well.*
(4) shrink.

However, it is a major surgical disgrace that not enough skin grafting is done, because it can do much to reduce suffering and disability.

FULL THICKNESS GRAFTS
give a much better colour and texture match shrink less, but *are very sensitive to infection & are more difficult to apply. They are really useful only on the hands and face.*

EQUIPMENT
WATSON KNIFE
N.B. (The Humby knife has a sliding roller which is less easy to use, and has no advantage)
SET of 50 spare blades
N.B. Autoclaving the blades make them blunt.
SKIN HOOKS HOOKS, single point, Gilles, stainless steel, 200mm, 4 only. With these, you least damage the skin when handling it. You can use fine dissecting forceps instead, but they may tear the graft.
SKIN GRAFT BOARDS, hardwood or plastic, with bevelled edges, 6x100x200mm, 2 only. These are rectangular boards with rounded edges to hold the skin taut as you cut the skin (50-xxA). However, you can use any conveniently shaped board, or even a wooden spatula.
N.B. You can (with practice) take a good skin graft with a well-sharpened carbon steel carving knife.
N.B. There is a miniature knife, developed by HLSilver of Toronto, which uses ordinary safety razor blades. Its disadvantage is that it can only cut a narrow strip of skin. Otherwise you can use a modified standard razor.
N.B. The electric dermatome can be set accurately, and gives a more reliable regular cut, but it is quite heavy, and you need practice, just like the Humby knife, to use it.

SKIN GRAFTING EQUIPMENT

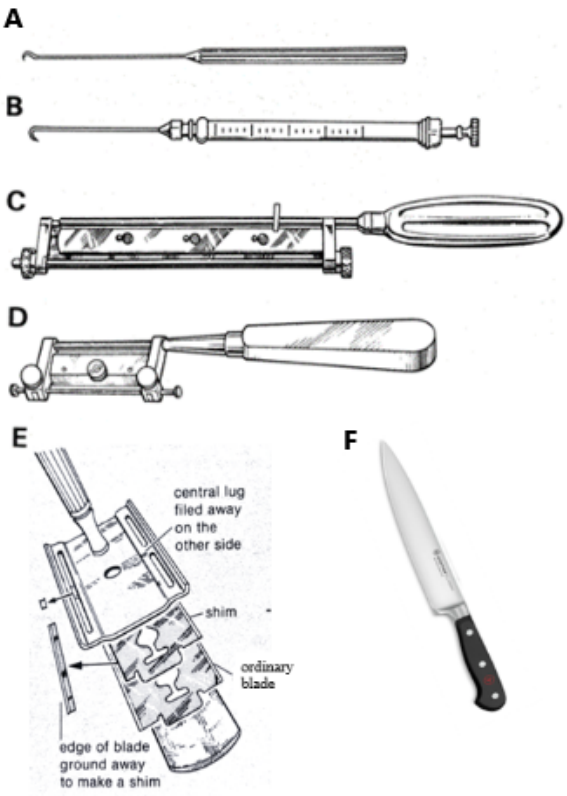

Fig. 50-10 SKIN GRAFTING TOOLS. A, skin hook B, home-made skin hook, C, Watson knife D, Razor blade holder. E, modified razor. F, carbon steel carving knife *With the kind permission of James Smith; kindly contributed by Peter Bewes.*

TECHNIQUE
You can vary split skin graft thickness by altering the setting of the knife. There are theoretical advantages of thinner & thicker grafts, but in practice, use a standard thickness (4-5mm).

Place the blade in place on the Humby knife & lock it in place. Check that the screw fittings gve an equal width at both ends of the blade, and that the blade does not wobble in its place.

Adjust the screws so that the gap between blade and roller is exactly how you want it, and then tighten the screws & locking nut to fix the position. You should see a thin sliver of light between blade & roller.
You should be able to slide the rod easily back & forth in front of the blade.

Don't use a faulty knife: it will disappoint you! Practice first on a bar of soap or an orange. and then on an animal limb from the butcher!

If you handle the blades carefully, you can use them several times. *But you cannot cut a graft with a blunt blade.*

Try to cover the wound with as few sections of skin graft as possible. The result is always better if you can use one 'sheet' to cover the wound completely.
You can expand the cover of a sheet by making a mesh. Do this by making cuts into the graft with an osteotome (50-15) or simple blade.

ADJUSTING A WATSON KNIFE

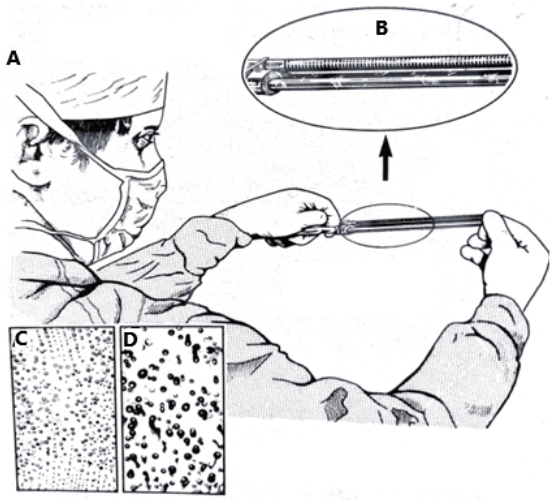

Fig. 50-11 ADJUSTING A WATSON KNIFE. A, Hold the knife up to the light. B, adjust the screws to check the gap between the roller & the blade. This should be 3-5mm (enough just to allow a razor blade through), and equal the length of the blade. C, undersurface of a thin split skin graft with small punctate bleeding. D, undersurface of a thicker graft. *Kindly contributed by Ian McGregor & Peter Bewes.*

This will enable you to increase the surface cover up to 6 times, depending on the number and closeness of the cuts. You can get a plastic template on which you place the graft, and pass this through a roller which looks like a miniature towel wringer.
However, at x6 expansion, the skin graft tends to curl up and then becomes difficult to manage and place nicely on a wound surface, so this is really only practical for x2 or x4 expansion.

IF POSSIBLE, USE SHEET GRAFTS
Remember that where there are gaps in the graft, the epidermis will need to grow across to heal. This will leave marks, and *so this technique is not useful for the face.*

PREPARATION OF THE WOUND SURFACE

You vastly increase your chances of a skin graft succeeding if the granulations on the wound are satisfactory. This is the purpose of desloughing (50.9).

Ideally, these granulations should:
(1) be firm, flat, rough, & bright red,
(2) bleeding on touch,
(3) have no significant discharge,
(4) have no sign of infection,
(5) show active epithelialization at their edges,
(6) have gently sloping wound edges.

Unsuitable granulations are:
(1) pale, avascular, & heaped up,
(2) slimy, soggy, oedematous, & friable,
(3) wet with a purulent or smelly discharge,
(4) accompanied by lymphangitis or adenitis.

Therefore, always scrape away most of the granulations from the base of a wound, unless they are very thin and have a very good colour. This reduces the fibrous tissue which will form under the graft & give a better cosmetic result with less likelihood of contracture formation.

If granulations are very unfavorable, excise and curette them, together with the fibrous base of the wound (50.9). Accompany this with frequent soaks using either (1) half-strength saline, (2) hypochlorite, (3) chlorinated lime & boric acid solution, (4) 0.5% acetic acid, (5) diluted hydrogen peroxide, (6) sugar, (7) honey, (8) yoghurt, (9) mashed fresh papaya, or (10) fresh placenta or amniotic membrane.
What you use is probably of less importance than how often you change the dressings.

DON'T GRAFT GRANULATIONS WHICH ARE HEAPED ABOVE SKIN LEVEL

SITES SUITABLE FOR GRAFTING

Split skin grafts readily take on:
(1) favourable granulation tissue (57.3).
(2) healthy red tissue in a fresh wound.
(3) dermis.
(4) muscle.
(5) any vascular tissue or organ normally covered by aeolar tissue. This includes paratenon, nerves, fascia, and blood vessels.
(6) periosteum.
(7) cancellous bone.
(8) pleura.
(9) peritoneum.
(10) meninges.
(11) gut.
(12) penile shaft.

Grafts take less readily on:
(1) fat.
(2) joint capsule.
(3) ligaments.

Grafts will fail to take (so a flap is needed) on:
(1) bare dry tendon, except in young children.
(2) bare cortical bone.
(3) hyaline cartilage.
(4) open syovial joints.

N.B. Split skin grafts look ugly on the face, and will rub off where there is constant pressure, such as the heel.

CAUTION! (1) *Don't try to graft a badly anaemic patient*. (2) *Don't try to graft too large an area at once:* 10% of the surface area is the absolute maximum at any one time.

METHOD FOR SKIN GRAFTING (GRADE 2.1)

(a) Preparation of the patient
Make sure your patient is well nourished, not anaemic & not febrile. The Hb level should be >80g/L. A recent pus swab should be negative. Use prophylaxis against *Streptococcus*: penicillin is simplest, with erythromycin asan alternative.

Once you are satisfied that the granulations in the wound are suitable, decide on where the donor sites should be. You can use depilatory creams, *but not immediately before surgery*. Make sure your patient gets a good bath pre-operatively, and scrubs the donor areas on the morning of surgery.

N.B. Don't attempt to take >10% TBSA skin graft at one attempt: this is equivalent to front & back of the thigh, or both thighs.

(b) Choice of donor site
You can take skin most easily from any convex surface of the body. The most convenient is the anterior thigh, which amounts to c. 5% TBSA.

The posterior, medial & lateral sides of the thigh, calf, medial & lateral upper arm, and medial forearm are also sites easy to use. Where large areas are burnt, you can also use the buttocks, calves, chest, back, head or even the abdomen.

(c) Preparation of the donor site
Scrub the donor site with cetrimide and a scrubbing brush, and then swab it with a mild antiseptic, such as hexachlorophane soap. *Don't use iodine or spirit,* because they may kill the graft. Drape round the donor site with drapes.

Raise a layer of diluted LA in a rectangle where you intend to obtain the skin graft.
The key is to get into a comfortable position, and get your assistant to hold the skin where you want to cut absolutely taut, and not to release the tension till you have finished the cut. Keeping the skin taut is more difficult in obese & elderly patients.

DONOR SITES FOR SKIN GRAFTS

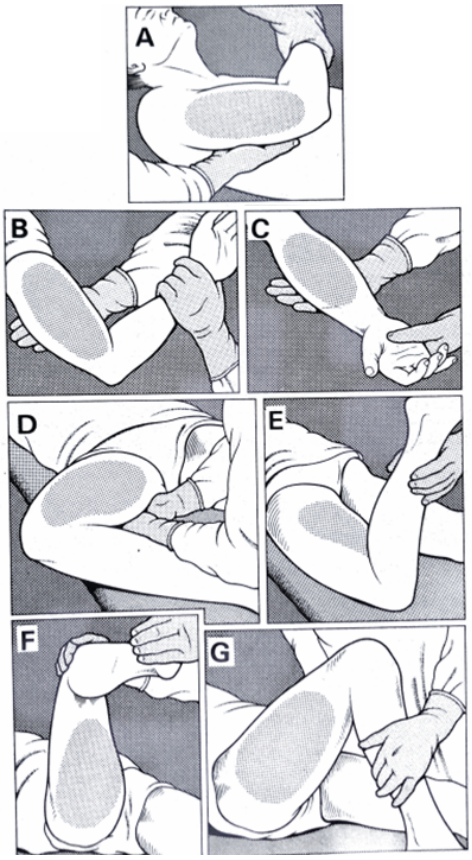

Fig. 50-12: COMMON SITES FOR SKIN GRAFTS. A, outer side of the arm. B, inner side of the arm. C, forearm, D, inner side of the thigh (usually the best place). E, back of the thigh (patient prone). F, back of the thigh (patient supine). G, outer side ot the thigh. *With the kind permission of Ian McGregor*.

Use plenty of a very dilute LA, such as 0.4% lignocaine with adrenaline, to raise the skin all over the donor site. By raising it like a plateau, it will be easier to cut (50-13).

For the thigh, you can use a regional femoral and lateral cutaneous nerve block.

CAUTION! The skin of the upper arm is thin, so *don't cut a full thickness graft by mistake*.

For the head, *be careful to not go beyond the hairline*. Shave the hair & infiltrate the subgaleal layer. Because you leave the hair follicles, the hair will regrow on the head, but not where you apply the skin graft.

For the chest, fill out the skin from between the ribs (especially in a thin patient) by injecting the subcutaneous tissues with saline or diluted LA, so as to make a flat surface.

DONOR SITE PREPARATION

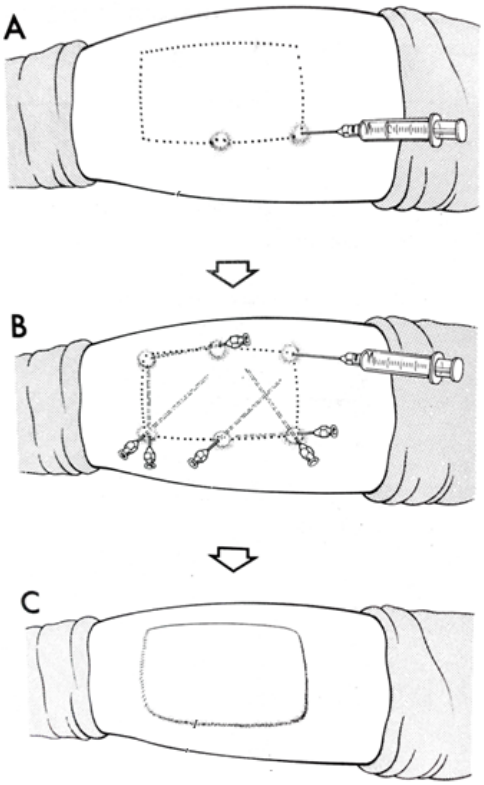

Fig. 50-13: LA FOR DONOR SITE PREPARATION. A, use plenty of a very dilute LA, such as 0.4% lignocaine with 1ml of 1;1,000,000 adrenaline. B, raise the skin all over the donor site. C, by raising the skin like a plateau, it will be easier to cut, and bleed less. *After London PS, A practical guide to the care of the injured, E&S Livingstone, Edinburgh 1967 with kind permission.*

For multiple sites, use ketamine.

(d) Harvesting the split skin graft Make sure your Humby knife (or dermatome) is correctly adjusted, the skin kept taut by your assistant, and the donor surface well lubricated with liquid paraffin (50-14A).
Press the Humby knife flat gently against the skin, keeping the board pressing firmly at 45^0 ahead of the rod, and, using a zigzag sawing motion, advance the knife from right to left, moving the board ahead at the same speed.
Make sure your assistant keeps the skin taut at all times.
The graft usually collects in folds on the knife. If it does not, ask the scrub nurse to pick up the ends of the graft with skin hooks.

When you have cut the skin you need, lift the blade slightly upwards, and left the skin ride past the rod. Then divide it with scissors, or do this beforehand.

SPLIT SKIN GRAFTING

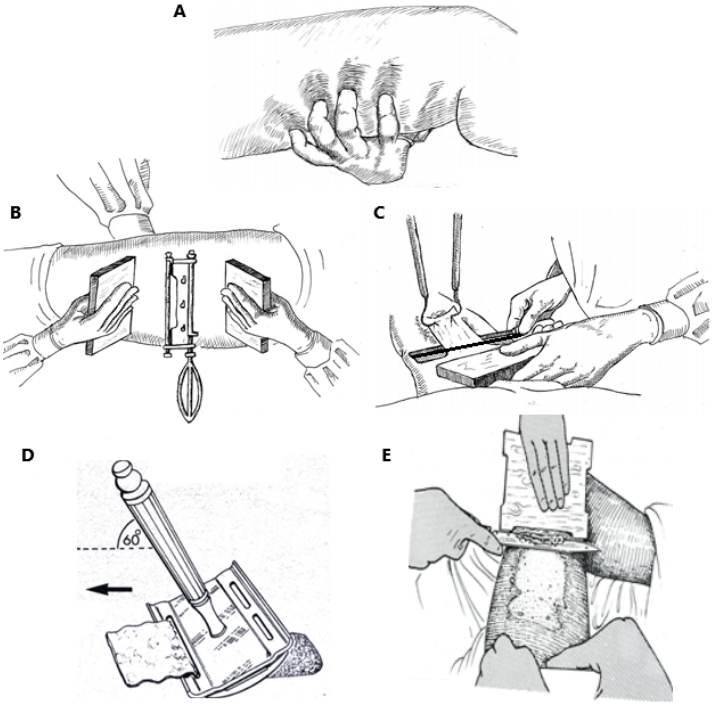

Fig. 50-14: HARVESTING A SPLIT SKIN GRAFT. A, One assistant is holding a board behind your knife, & the other hand keeping the skin taut. B, An assistant holding the skin with hooks. C, gripping the thigh taut. D, using a modified razor. E, using a carbon steel carving knife. *Kindly contributed by Peter Bewes.*

CAUTION!

(1) *Don't force the knife down the limb:* you will make too deep a cut.

(2) *Don't stop or pull the knife backwards*.

(3) Take a little more graft than you think you may need.

(4) Place hot moist dilute adrenaline packs over the donor site to reduce bleeding, and elevate the limb.

If after cutting c. 1cm of graft, you think the graft is too thick (or, rarely, too thin), *stop!* Assess the graft thickness by its tranlucency. If it is like tissue paper, it is too thin. If has large bleeding points, and curls up, it is too thick.

If you have cut into fat, *stop,* close the wound with fine sutures, decrease the blade-roller distance, and start again.

It is a good idea to lay the graft upside down onto a solid surface, preferably plastic, prior to placing it onto the wound site. Though pigmented skin looks bluish & shiny on its underside, white skin looks very similar whichever way up!

If you place the graft upside down on granulation tissue, it won't take!

Alternatively, place the graft onto paraffin gauze, and flatten it out as it tends to curl up.

It is useful to pierce some holes in the graft, so that exudate can drain through it, without lifting it off the granulation tissue surface.

MESHING A SPLIT SKIN GRAFT

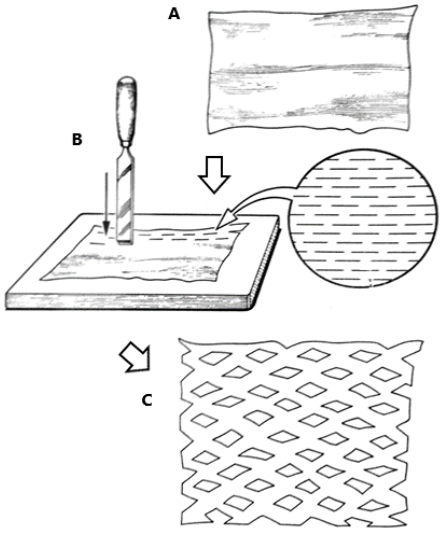

Fig. 50-15: MESHING A GRAFT. A, the sheet of split skin. B, cutting holes into the split skin. C, spread the graft, so increasing its cover; use mesh grafts for extensive areas. *Kindly contributed by Peter Bewes.*

Then carefully place the graft onto the wound surface. Trim it to shape. If you have to use several pieces of graft, lay them edge to edge, and let them overlap the edges of the wound a little. Make sure that they fit snugly to the bottom of any irregular areas, and *don't bridge any concavities*.

If sheets of graft cross a joint, *try not to make a join in the joint*; if you cannot avoid this, make sure that the join (where a scar may form), lies transversely across the joint, *not along it*.

It is best to suture a single sheet graft in place to stop it moving about, though this is not essential, but advisable at sites with much movement such as the eyelids, the palmar surface of the fingers, the axilla, and the popliteal fossa. Use small curved needles and fine non-absorbable sutures. Insert the needle from within outwards.

If you need to cut more skin grafts, cut the graft thin so that you can take another crop of skin from the same donor area 15 days later.

If the graft is over a joint, put a plaster cylinder over the dressings.

If the graft is over a flexure, the position in which the limb rests is critical (50.11), to prevent contractures.

(e) Dressing the grafted wound
APPLYING A DRESSING

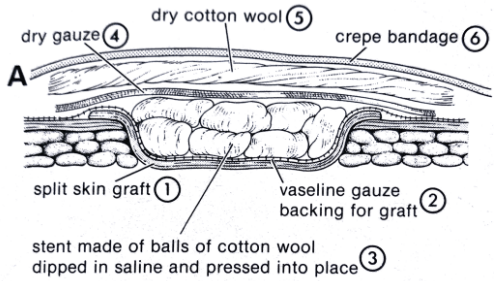

Fig. 50-16: APPLYING A DRESSING. A, The 1st layer is the graft itself, sticking to its backing of paraffin gauze (B). The gauze, but not the graft itself , should extend well beyond the edges of the wound. C, the next layer acts to mould the graft onto the concavity of the wound. Make it by fluffing out some balls of cotton wool, dipped into a bowl of saline, and while they are still dripping wet press them gently into place over the graft. They will mould themselves to any of its concavities. Alternatively use enough layers of gauze. Make sure that the bandages applied subsequently exert even pressure. D, next apply a final layer of dry gauze, and let it overlap the edges of the wound. E. then apply some dry cotton wool. F, hold it in place with a crepe bandage.
In children you often need plaster bandage to prevent movement. *With the kind permission of Peter London*

THE TIE-OVER METHOD

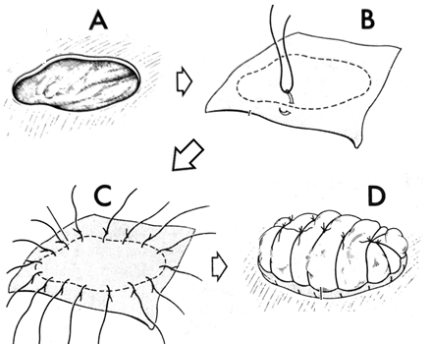

Fig. 50-17: THE TIE-OVER METHOD is a useful way of dressing a graft sutured in a place awkward for dressings. Use it for eyelids, the axilla, and for small intricate grafts, such as those over the tips of fingers. A, the wound. B, the graft placed over it. C, sutures all around, put from inside out. D, sutures tied over a thick dressing. *Kindly contributed by Peter Bewes.*

CAUTION! The graft must not move over its bed. In a child, this may be difficult to prevent, so you may have to use a frame, or apply a cast.

If the graft site is oozing, apply a negative pressure suction dressing.

(f) Dressing the donor site
The donor site always bleeds, and if it is large, much blood may be lost. When you have applied the graft and dressed it, remove the pack on the donor site and replace it by paraffin gauze, plain gauze, and a pressure bandage. Leave this for 7-10 days and then remove the dressings.

THE DRESSINGS ARE CRITICAL:
DON'T ALLOW A GRAFT TO MOVE DURING BANDAGING OR AFTERWARDS

If the donor areas itch and the patient scratches it, sedate him, re-dress the wound, and consider applying a cast.

If the dressings have stuck to the donor site, leave them in place till they fall off. If you tear them off, *the wound will be very slow to heal.*

If the donor site becomes infected, treat it as any other superficial wound with frequent cleaning and changes of dressings.

(g) Removing the dressings
REMOVING THE DRESSINGS GENTLY

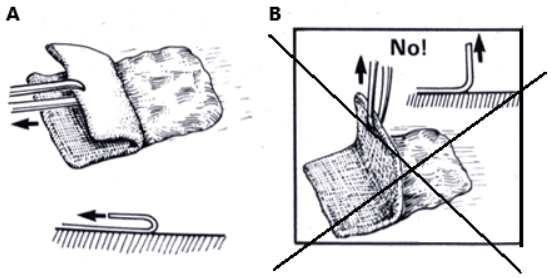

Fig 50-18, REMOVING THE DRESSINGS A, the right way, so as not to pull newly adherent graft away from the surface. B, the wrong way, *From Yang CC, Hsu WS, ShihTS (eds.) Treatment of Burns, Springer 1982, with kind permission*.

Leave the dressing on *unless there is a smelly exudate*. In this case remove the dressing very gently. You may still save the graft if you can keep it on the wound site.

At the 10th day*, change the dressing yourself, so that you can inspect your handiwork*. *Don't let your nurses do this, however competent, because you will not know, if your graft has failed, what the problem was.*

At first carefully remove only the superficial layers, using plentiful soaks. Leave the layer of paraffin gauze which was used to spread the split skin. Remove this only if the graft is firmly adherent.

If you see any blood clots under the graft, remove them. Wash them away from under it with saline, a syringe and a blunt needle. If some clots still remain, pull them out with non–toothed dissecting forceps. Immediately apply pressure to control further bleeding. Leave the graft in place for 3 more days.

Use paraffin gauze for the first dressing only on a successful graft. If you use it repeatedly, granulomas may form.

If there are any granulating areas, clean them gently with saline. If they cover a significant area, regraft this when granulations are suitable, if possible, with stored skin.

If blisters appear, incise them, or aspirate them with a syringe.

Start active joint movements 1 week after grafting. After 2 weeks you can usually remove all dressings.

N.B. It is possible to treat skin grafts without dressings, by simple exposure. This is economical, and well suited to warm countries, but beware flies & mosquitoes! You can also observe a graft and express fluid from underneath it more easily. The graft surface needs to be clean with good granulations & the grift secured with sutures. The patient needs to co-operate, not scratch the graft, and be very attentive not to damage the graft. You need to swab away excess fluid every 2h. Nurses need to understand this still needs *active* care!
It is useful for large areas on the back, the face & perineum where dressings are difficult.

(h) Graft failure
Grafts should take on any wound you have made surgically, such as one at excision of a contracture. For burns and other potentially infected wounds, there the most important reason why grafts don't take is lack of preparation. However, even if you have optimized the granulations as best you can, a graft will not succeed if:

(1) The wound is infected, particularly with *Strep. Pyogenes*, which secretes an enzyme that destroys the fibrin that sticks the graft to the wound.

Suspect it is present if the growing epithelium at the side of the wound has a sharp edge, instead of a normal gently shelving one. Routine prophylaxis should prevent this.
Pseudomonas, which give a greenish tinge to the wound and have a smell like rotten bananas, can also cause a graft to fail. Gentamicin is the antibiotic of choice, though *Pseudomonas* is notorious for developing resistance.

(2) The graft is lifted off the wound surface by exudate or bleeding. If you see this happening when you are applying the graft, make sure you have fenestrated the graft with stab wounds. Wait till the oozing stops. If necessary, store the graft for re-application after 2-3days.

(3) The graft is moved from the wound. Even a slight motion in the first 2-3days can shear tiny blood vessels growing from the graft bed to vascularize the graft. So suture the graft at its edges & make sure the dressing is firm, and if near a joint, immobilized with asplint or plaster.

(4) The patient is malnourished, anaemic, or in renal failure.

(5) There is a very poor vascular supply at the site of the graft, *e.g.* in diabetics.

(6) You have put the graft on upside down!

(7) The graft comes from another patient! However, in the very rare case when your patient has an identical twin, you could use the sibling's skin if there is a dire need!

(i) Storing grafts
You can store a graft in the ice compartment of an ordinary refrigerator. Stick its upper surface to paraffin gauze. Roll it in gauze moistened with saline, with its raw moist surfaces together. Keep paraffin away from the undersurface, or it will prevent the graft taking. Put the roll in a sterile screw capped bottle labelled with the patient's name.

You won't need any anaesthetic to apply the stored graft, and you can do this, with sterile precautions, in the ward. Unroll the bundle, cut the paraffin gauze to the required size, and lay the graft on the wound. The sooner you apply it the better.

We suggest you discard grafts after 8days, although they may keep for 2-3 weeks.

If you have taken more graft than you need, put it back on the donor site. You will still be able to use it within 4 days by lifting it off gently.

(j) Pinch grafts
These are effectively a a combination of a full thickness and a split skin graft. You pull up the skin, and cut off little pieces off; the centre is full thickness skin, but the circumference is epidermis only.

Pinch grafts are easy to cut, they resist infection well, and because they contain some full thickness skin, they resist pressure better than a split skin graft; this makes them useful on the heel, or over the Achilles tendon.

Pinch grafts leave an ugly donor site, unless you make a decorative patern of cuts (which you should discuss with your patient!)

Pinch grafts are so easy to take, and need no special equipment, they are particularly useful in peripheral health centres.

THE MOST FREQUENT FAILURE OF BURN CARE IS NOT DOING ENOUGH SKIN GRAFTING!

50.14 Special burn scenarios

(a) Deep burns to the face
If the diagnosis of a deep burn is reasonably certain, excise and skin graft this. Where the depth is clear-cut at the outset, graft the face after 3-4days (50.12). Always use sheet grafts and apply them in aesthetic units if possible. Use sutures for tie-over dressings (50-17) or simple fixation. *Don't mesh the graft.*

Clean regularly around the nose and mouth afterwards.

(b) Burns around the eyes
Burnt eyelids are much more common than burnt eyes. If someone is awake, shutting the eyes is a natural reflex. So, the cornea are spared unless consciousness is lost.

However, sight is still in danger from the burns of the eyelids, or from late effects of scarring. Burnt swollen eyelids will cover the eyes for a few days, but if they are seriously burnt, they will contract, particularly the lower ones, and expose the cornea, forming an ectropion (28.10).

This may result in conjunctivitis, exposure keratitis, corneal ulceration, perforation, and finally infection of the globe.

AVOIDING EYELID CONTRACTURES

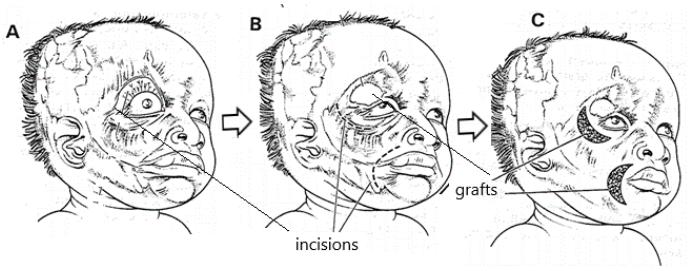

Fig. 50-19 AVOIDING EYELID CONTACTURES. A, excise the everted upper eyelid. B, after grafting, but leaving a lateral contacture. C, further release, also at the lips. *Kindly contributed by Randolph Whitfield II.*

Prevent this tragic sequence of events by making sure that the cornea is always covered and moist. The easiest way to do this is to use an antibiotic eye ointment every 6h. The most radical way is, temporarily, to sew the eyelids together (tarsorrhaphy, 28-13). Keep sutures in the eyelids, so you can retract them by pulling on the threads.

Don't worry too much about what the patient's eye looks like at this stage. What matters is not to leave the cornea exposed.

If there is a 3rd degree burn of the eyelids, excise it & put a full thickness skin graft (28-14). Grafts take well on eyelids, so that grafting them is not as difficult as you might think.

Often contractures continue to form, so that a release is only partially successful, and needs repeating (50-19), maybe 2-3 times.

CAUTION! Stretch the lid first so that there will be some slack tissue when it contracts later. The thinner the graft, the more the shrinkage.

Treat chemical burns in the same way. As with all chemical insults, use vast quantities of water to wash them at the earliest possible moment.

Examine the eyes fully early, preferably before eyelid swelling starts. If the eyelids are very swollen, you'll need gauze and sterile gloves, and maybe eyelid retractors. A bright shiny cornea is a good sign. Stain it with fluorescein and look for ulceration.
There are 4 grades of corneal injury; in I & II, the prognosis is good.
I. Epithelial injury only.
II. Cornea hazy but iris clear.
III. Total epithelial loss, and stromal haze.
IV. Cornea opaque completely obscuring the iris & pupil.

If the cornea is hazy, apply chloramphenicol ointment, and atropine or homatropine eye drops.

If there are foreign particles in the eyes, irrigate them away with water or saline.

If the punctae or canaliculae are damaged, pass a style or indwelling suture through them to keep them open, as they heal.

If the palpebral and ocular conjunctivae begin to stick together, separate them with a smooth glass rod.

If all or most of an eyelid is destroyed, dissect the conjunctiva of the lid free of the *orbicularis* muscle and tarsal plate, and cover the globe by suturing the remains of the lids together. Graft their exposed surfaces.
Refer to an expert later. If an eye is hopelessly damaged, it will have to be removed at some stage.

If the cornea is exposed, **and above efforts fail, & the eyelids are charred and tight**, make relaxation incisions, if necessary combined with traction sutures from the cheeks.

Try especially to prevent retraction of the upper eyelids, because these protect the cornea during sleep.

CAUTION! (1) *Don't use steroids.* (2) *Never apply an eye pad directly to the cornea*, because it may rub and ulcerate through. *Even paraffin gauze can cause ulceration.*
If you are unable to cover the cornea by the eyelids, just make sure you keep the open eye covered with an antibiotic gel.

(c) Massive facial burn
Warn a patient's family that massive oedema may greatly distort the facial appearance, but that this will disappear. Raise the head to 30° and administer oxygen.

The most significant acute risk is loss of airway patency, so have intubation and tracheostomy equipment ready (42.1). If a cricoido-thyroidotomy is necessary, *don't try this outside the theatre*. Try intubating first if possible. Get everything ready! Find the person with most experience, as often there is only one chance and then the larynx goes into spasm, the swelling then increases with each failed intubation attempt.

Oedema will be at its maximum 12-24h after the burn, so monitor the patient carefully, because respiratory obstruction may be sudden.

Full thickness burns of the beard area are rare, because the hair follicles extend so deep.

The most common cause of graft failure is movement of the graft.

(d) Burns of the ears
Inflammation of the ear cartilage can occur 2-5wks after a severe facial burn, when the skin over the ear may have healed. The burnt ear becomes acutely, painful, red, and tender, because its cartilage has become necrotic. Unless you excise the dead cartilage, it becomes infected and sloughs. Once this has happened, an ear needs reconstruction.

Dress a burnt ear carefully, putting a pad of gauze behind it to prevent it bending. If a fluid collection gathers on the ear, incise and drain it urgently, if necessary, more than once, *otherwise the cartilage under it may necrose*.

If the ear cartilage does become necrotic, incise the outer border of the ear, so as to separate its anterior and posterior surfaces.

Remove any soft yellow cartilage which lacks the normal resilience of healthy hyaline cartilage. Pack the ear with fine gauze, being careful not to bend it (50-20).
Keep it moist with saline. Examine it 24h later, under LA. If necessary, remove more necrotic cartilage. If there is sepsis and abscess formation, drain it with a wide incision, and remove all necrotic tissue.

EAR CARTILAGE DEBRIDEMENT

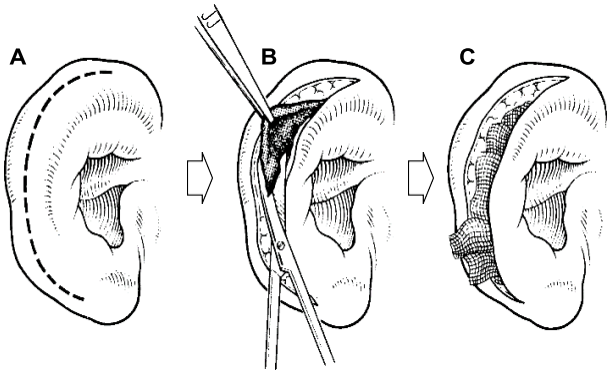

Fig.50-20 DEBRIDEMENT OF NECROTIC EAR CARTILAGE. A, incise the helix. B, dissect out the necrotic cartilage from under the skin. C. pack the cavity with paraffin gauze.

(e) 3rd degree hand burns
For deep partial thickness burns, use the plastic bag method,

N.B. To practice tangential excision you need skill, so do this if only 1-2 fingers are affected, and graft within 3-5days.

If burns have exposed tendon, bone, cartilage, or joints, the patient is usually in so much pain that you cannot find out if his nerves and tendons have been injured or not. The hand requires skin flaps, which is a highly skilled task, so try to refer him.

If a burn is very severe, you may have to amputate, but don't do this unless it is absolutely necessary. The same indications for amputation (60.2) apply in burns as in other hand injuries. Early excision & grafting will be the only way you can hope for reasonable function in the fingers.

Dressing fingers will almost always make them stiff. The expose method is probably the simplest initially. However, or messy wounds, you can use the plastic bag method (50-21). This keeps the fingers moist and allows movement, which is reasonably comfortable and almost completely painless. It is critical that the all the joints move through their full range on an hourly basis. *If not, they will end up with stiff swollen fingers which will lead to contractures.* Stiffness appears very rapidly, but takes wks or months of therapy to overcome, once established.

PLASTIC BAG METHOD FOR HAND BURNS

Fig. 50-21 PLASTIC BAG METHOD FOR 3rd DEGREE HAND BURNS. Use big sterile bags: this keeps hands moist & mobile.

You can use the plastic bag method for up to 5days. Use any big sterile plastic bag of a suitable size.There must be plenty of room for the hand to move about inside. *Don't use a plastic glove.* Smear the hand in either silver sulphadiazine 0.5%, or povidone iodne with a little more of the same antiseptic, and place it inside the plastic.

Wrap a piece of gauze round the wrist and hold it in place with a piece of strapping and gauze to form a watertight seal.

Remember a burnt hand swells alarmingly, so elevate & suspend it. *Ensure the patient moves and uses the hand inside the bag right from the start.*

Large volumes of murky fluid will collect in the bag: this is normal. Change the bag twice a day; take the hand out of the bag, wash it with soap and running water. Apply more antiseptic, and put it back in a new sterile bag.

Full thickness burns of the digits inside a plastic bag may still need an escharotomy, so observe the circulation in the fingers carefully.

N.B. Sloughs will usually fall off in pieces into the bag by themselves, so that desloughing with scissors is usually unnecessary.

It's not easy to see inside the bag when a hand may be ready to graft: *never make this decision without looking at the hand outsuide the bag!* Once some granulations have appeared, it's usually time to remove the remaining slough by rubbing or excision and apply grafts. You should do this before 2wks.

A hand which stays uncovered longer than this is more likely to develop severe contractures. Once you have grafted hands, *don't put them in a plastic bag!!* Splint and dress the fingers & then mobilize the hand when the grafts have taken.

Splinting in the correct position helps prevent contracture formation; however, if splinted for too long without exercise, stiffness can still develop.

Splint hands at night and mobilise them as much as possible during the day. After grafting, it is important to keep the splints on continually for at least 5 days or until the graft is well adhered.

A plaster cock–up wrist splint is generally the best with the wrist slightly extended, the mc joints at 90^{o} and the ip joints in full extension (65-8). Place the splint outside the dressing or the plastic bag and then bandage it in place. Keep a pad or splint in the space between the thumb and index to prevent an adduction deformity.

If you decide to dress a hand burn, put paraffin gauze between the fingers to prevent them sticking together and forming bridging webs. Cover each finger separately, and change the dressings daily. Dress the hand and splint in the position of safety (65-8) .

DISASTERS: STIFF HANDS

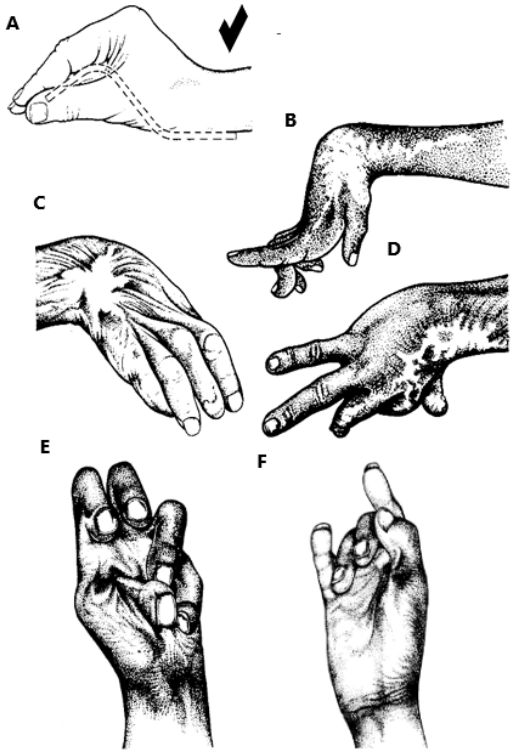

Fig. 50-22 DISASTERS WITH BURNT HANDS. If the methods described here had been applied, almost none of these disabilities and deformities would have occurred. A, the correct position for splinting. B-F results of not splinting the hand.

If there are exposed joints, aim for an arthrodesis in the position of function (usually 30^{o} of flexion at the ip & mp joints). Remove any dead cartilage and fix the position with crossed K-wires, left in place for 3wks.

If a single finger is fixed in significant flexion, try to release the contracture & place a tissue graft; however, depending on the function of the hand and the wishes of the patient, it is often advisable to amputate it, *if it is interfering with function of the rest of the hand*.

(f) 3rd Degree foot burns

Feet are often burnt in children walking barefoot on ashes. Whilst the foot is not as complex a structure as the hand, contractures of the toes will prevent walking. Also, the skin of the sole is special and hard-wearing, so a simple skin-graft from elsewhere will not replace its function.

So, splint the toes straight (you need K-wires to do this effectively) and do your utmost to prevent infection, which worsens the burn wound.

High voltage electric burns often involve the foot which then requires extensive debridenent. *You may get a better result finally with an amputation & prosthesis.*

(g) Perineal burns
The perineum is an area where it is almost impossible to keep dressings clean, so use the exposure method (50.9). Avoid urine and stools soiling the wound by catheterization, and the creation of a diversion colostomy (11.5). Avoid excision and grafting before this is done.

The testes may be involved in young boys, and the labia in girls. You may have to bury exposed testes in a pouch under viable skin. For labial burns, you may have to use techniques as in de-infubulation for FGM (47-6).

N.B. Up to 50% of perineal scalding in children is from abuse!

N.B. Sepsis in the perineal area may rapidly lead to Fournier's gangrene (6-16).

N.B. Drinking white spirit may give rise to an 'alcoholic' watery diarrhoea which can produce a nasty perineal burn.

(h) Child scalding:
Scalding in children, usually by hot water, most often produces mixed depth burns with the majoirity being 2nd degree with areas of 3rd & 4th degree. It is often difficult to determine the depth initially and the appearance will tend to change over the first few days.

However, the aim of management is to achieve complete wound healing within 3wks as this minimises the risk of hypertrophic scarring.

A reasonable approach is therfore to treat the burn conservatively with dressings and topical antimicrobials for 10-14days. If there are significant areas that have not healed by this stage then excise and graft these areas. Use meshed sheet grafts when possible.

(i) Burns of the trunk
Follow up a child with severe burns of the trunk carefully. As growth occurs, scarring may prevent normal breast development or chest wall movement. At puberty, you may need to release more scar tissue.

Make a semilunar incision just below her contracted breast. Continue it into her intermammary cleft. Cut down to the deep fascia, lift the breast upwards, and correct its position by gauze and scalpel dissection.

Apply split skin grafts, and hold them in place with tieover sutures over wet wool. Cover them with dry wool and crepe bandages. Unless you can supply a firm elastic chest covering, make sure she lies flat until the grafts have taken.

If the nipples have been totally destroyed, you may need to suppress lactation in case of childbirth.

Likewise, an abdominal scar may need releasing to allow for pregnancy.

(j) Exposed (not necessarily burnt) bones
The tibia, the ulna, and the skull are often burnt when an epileptic falls into the fire. If the tissues over the periosteum are burnt, the latter dies, and with it the bone underneath, even if it had escaped previous injury. As you debride the slough or it falls away, you may see greyish yellow bone protruding from among pink granulations round the edge of the burn.

Granulations don't form on dead bone, although they sometimes form under it as it separates, so speed up this process by chiseling away dead bone, until you see some bleeding which shows that you have reached living bone. Wait for granulations to form, usually in 5 to 10 days. Then apply split skin grafts.

N.B. For treatment of contractures, which are not always caused by burns, see 34.2.

50.15 Electrical burns

Electrical burn injuries are a significant cause of morbidity and mortality, arising as a result of domestic, occupational accidents & lighting strike. They are frequently associated with being thrown, falling from a height, and combined with violent muscular contractions. This may directly affect the heart, causing an arrest in systole, or respiratory muscles, producing apnoea.

Unlike other burn injuries, the visible area of burn may only represent a fraction of the total amount of internal tissue damaged. In an electric shock, the current passes in and out of the body at two points, which are indistinguishable and small, often white or grey and insensitive.

Current, $i = {}^{V}/_{R}$, where V is voltage and R resistance. Direct currect causes muscle contractions, and can throw a victim (*e.g. in a lightning strike, or from a car battery)*, or cause unrelenting grasp on a cable, whilst high frequency alternating current does not.

Very high voltage may arc across a gap and jump 2-3m per 10,000V, so an adolescent climbing to the top of a railway carriage can easily be electrocuted from overhead high tension wires, even without standing up.

A lightning strike fans along the ground, so if it hits a tree and you are near that tree, you are in danger! You are best off standing than lying down, and better off inside a house or car.

Damage to the body depends on the route taken by the current: if this traverses the heart, dysrhythmia is likely, along with other tissue damage.

The heat generated (causing most damage) is proportional to the resistance, which is greatest in the skin (even when wet), and then bone, fat, muscle & body fluids. Thrombosis in veins and arteries of limbs is a frequent consequence. *The later use of anticoagulants does nothing to reverse this!*

Voltage over 500V can cause deep burns, but low frequency alternate current of only 60mA may cause ventricular fibrillation. (A pacemaker supplies <1mA.) Household voltage is usually <250V, but higher to an electric stove. Industrial voltage may be much higher.

The striking feature in a survivor may be the absence of any alarming signs.

The 1st action must be to remove the electrical supply from the victim, either by switching off the current, pulling a cable away, or removing the victim from something metallic with a non-conducting implement. *Take care not to electrocute yourself!*

You may need to initiate CPR (44.9), and continue this for along time. *Remember that most people with electrical injury don't have underlying heart problems!*

Next, make sure you administer good amounts of Ringer's lactate, as the major problem will be fat & muscle damage (resulting in rhabdomyolysis & myoglobinuria, staining urine red) which will damage the kidneys.

Maintain a urine output >2ml/kg/h, & administer mannitol 25g 6hrly in adults with a continuous infusion of 5% sodium bicarbonate to alkalinise the urine.

Significant swelling of the limb is likely to cause a compartment syndrome (49.6), so prepare for fasciotomies. Where there is significant tissue necrosis, you may need to amputate. At any rate a second-look & serial debridement are. usually necessary in high voltage injuries.

Assess the contact points (which may need debridement), and any other chest, abdominal or sleletal trauma from falls.

Monitor with an ECG trace if possible: in about 30% there are dysrhythmias. Carefully follow the urine output – *this is important!*

N.B. A shock which may not affect a pregnant woman much may be lethal to the fetus!

You will be able to treat minor, low voltage, partial thickness burns conservatively.
High tension injuries will almost always require early fasciotomy, exploration and extensive debridement.

Any 3rd & 4th degree burns need excision; explore deep muscle compartments, carrying out extensive fasciotomies. Remove all devitalised muscle, but preserve tendons and nerves, if possible, especially if they show anatomical continuity.

A child who takes an electrical cable into the mouth may sustain deep damage to the lip, which results in a secondary labial artery haemorrhage 7days later.

N.B. Severe electrical injuries often need expert care; local flaps from the zone of trauma are not advisable, especially in high voltage injuries. Secondary procedures, such as nerve & tendon grafting or tendon transfers may be needed to rehabilitate these patients.

50.16 Chemical burns

A huge number of chemicals can produce burn injury, including acids, alkalis and organic solutions, as well as powders in weapons such as phosphorous bombs.

The amount of tissue damage is related not only to the substance involved and its concentration but also on the length of time the body is exposed to the toxic chemical.

Chemicals act in different ways: some by coagulation (direct necrosis of tissues), saponification (an alkali converting fat to soap), or heat on contact with water in the skin.

The severity of a chemical burn and its area of contact may often be difficult to assess initially. In addition, systemic toxicity is not uncommon and can result from apparently minimal contact.

Eye injuries are frequent and often result in blindness.

The 1st action must be to prevent further spillage of the chemical agent and to decontaminate anyone who has been in contact by:
(1) brushing off any chemical powder
(*N.B. you must wear gloves & protect eyes*)
(2) cutting away clothing
(3) removing any constricting articles (such as belts and rings)
(4) removing contact lenses if worn.

THE SOLUTION TO THE POLLUTION IS DILUTION!

Irrigate the affected areas with huge amounts of water! Remember that acid concentrations are measured in logarithmic scales, so you need 10 times the volume to change the pH by 1.

Wash the victim early for a prolonged period of time (at least 2h). A continuous flow of clean water will dissipate the heat as well as diluting the chemical. (In cold climates, you may have to use warm water to avoid inducing hypothermia.

Burns of >10–15% TBSA require formal fluid resuscitation and monitoring.

A simple two-layered paraffin &h dry gauze dressing followed by wool and crepe will usually suffice in the initial stage.

(a) Acids
Acids cause injury, firstly by protein breakdown and hydrolysis and secondly, by heat. Dessication, coagulative necrosis and direct thermal damage result. The result is usually a hard yellow-brown leathery eschar which then prevents further penetration of the acid.

N.B. Salicylic acid used as a skin paste for acne can cause a burn if used in excess!

N.B. Hydrochloric acid (used in making fertilizer, dyes, textiles, rubber & electro-plating) *gives off chlorine, which is noxious & can cause oral burns, laryngeal oedema and pneumonitis.* Observe then for airway burns and later stenosis.

N.B. Hydroflouric Acid (used in glass & metalwork & electronics) *gives off fluorine, which is even more toxic, and combines with calcium and magnesium to form insoluble salts.* This leads to hypocalcaemia and also release of intracellular potassium, causing severe pain, and greyish discolouration, turning black later. Monitor for ECG changes, airway burns and stenosis later.
This is where an antidote of copious application of 2.5% calcium gluconate gel & sub-eschar injection of 10% calcium gluconate may be life-saving . Add 20ml 10% calcium gluconate to the first litre of resuscitation fluid. *Death may occur with as little as 5% TBSA hydrofluoric acid burn owing to severe hypocalcaemia!*

N.B. White phosphorus converts to phosphoric acid when wet. It burns terribly because it sticks to the skin. Copper sulphate will inactivate it.

(b) Alkalis
Alkalis (in detergents, ammonia & bleach, and from Lithium battery explosions, 46.15) cause massive extraction of water from cells, reaction with tissue proteins and saponification of fats (forming soap). Such burns often initially appear less dramatic than acid burns but cause deeper injury. A slow penetrating deep burn results with a soft friable eschar. The injury may progress many hours after exposure, and so needs prolonged washing.

N.B. Calcium Oxide (Cement) is an alkali, and prolonged contact can give very deep burns. (It is also used in paper making, insecticides & the steel industry)
Mineral oil may be more effective than water in metal alkali burns.

(c) Organic Solvents
Organic solvents (*e.g.* in hair dye, nail varnish remover, as well as **petrol**) dissolve fat, have an anaesethetic action and are highly toxic to the lungs. The skin protects, but inhalation can lead to renal, hepatic,cardiac, respiratory and CNS failure.

N.B. Hot tar is petroleum-based but sticky, so adheres to the skin. Don't try to pull it off or soak it off with solvents as you will pull off the skin as well. Cool it down with cold water and then use butter or sunflower oil to rub off the tar, and then apply burns dressings.

N.B. Large body surface area chemical burns are often fatal owing to systemic effects of absorption as well as severe tissue damage.

(d) Chemical eye Injuries
Whilst the eyes close spontaneously to fire, heat & light, a splash to the face may easily involve the eyes also, and cause either direct corneal damage, or later, exposure keratitis.

Always irrigate the eyes with copious quantities of warm clean water for over 2h; apply an antibiotic eye ointment. Prevent expose keratitis by a tarsorrhaphy (28-13) if the eyelids are badly damaged.

Special treatments such as amniotic membrane transplantation may save corneas, so try to refer such a victim to a special eye centre.

50.17 Cold injury

It might appear that cold injury should not occur in hot climates, but nights are still often cold, and at high altitudes, snow persists even at the Equator.

Frostbite describes 'cold burns' affecting usually the fingers and toes, but may affect the ears, nose & lips. The depth of injury parallels other burns:
1st degree: numbness & erythema only,
2nd degree: superficial blisters, erythema & oedema,
3rd degree: deeper haemorrhagic blisters, & damage into reticular dermis,
4th degree: necrosis extending to deep tissues,
Simple injury is easily reversible, *though a loss of sensation and so absence of pain may give a false sense of security!*
More severe injury is characterized by ice crystals forming within the tissues.
Rewarming, where there has been ice formation results in swelling of the tissues, which may give rise to a compartment syndrome (50.5).

In most cases, especially if the injury is <24h old, rapidly rewarm the frostbitten parts in a water at 40^0C over 30mins, making sure the injured skin does not touch the sides of the bath or pot. As the water cools, you will need to replace it with newly warmed water.
N.B. Prevent the parts from re-freezing! Do not rub frostbitten fingers! Do not puncture the blisters!

Then elevate the limb affected. Use NSAIDs or opiates for pain control.

Where tissues do not respond to rewarming, you will need to carry out an amputation, but this is not urgent.

50.18 Friction burns

Large abrasions disrupt the skin to varying depth, and act exactly like burns of equivalent depth. These abrasions may be relatively clean, if incurred indoors, *e.g.* from a treadmill belt or vacuum cleaner, but are more often contaminated especially if the result of being dragged along a road.

They are often overlooked when associated with other (usually more severe) injuries. However, they may contribute significantly to fluid and blood loss.

If not debrided (as a septic burn should be), they can give rise to necrotizing infection and severe sepsis. This is more likely when there is an underlying internal degloving injury, where the subcutaneous tissues are ripped off the fascia, creating a significant haematoma.

This is known as a Morel-Lavalle lesion, and is rare, but easily diagnosed by ultrasound. *You must drain the fluid collection* oterwise sepsis will inevitably ensue.

MOREL-LAVALLÉE LESION

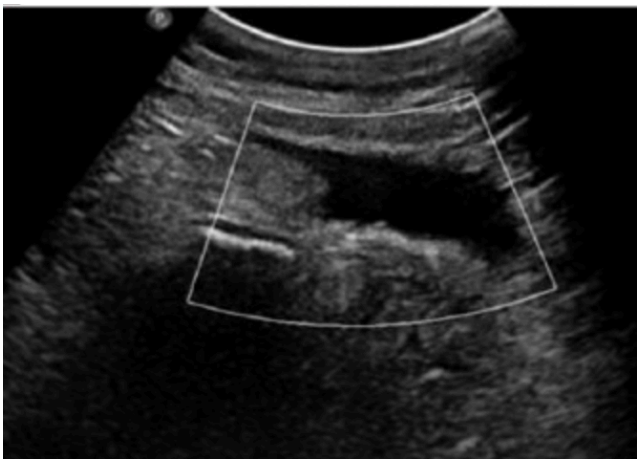

Fig. 50-23 Morel-Lavallée lesion: a large subcutaneous fluid collection seen on ultrasound. *After Nair Av, Nazar PK, Sekhar R, Ramachandran PV, Moorthy S. A closed degloving injury that needs real attention. Indian J Radiol Imaging 2014; 324(3): 288-90.*

Friction burns in children are common on the hand, but may occur on the buttocks, back and legs from water slides.

In younger adults, they are common in motorcycle riders not properly protected by a thick leather jacket. In such victims, >50% of friction burns are 3rd degree depth.

They may also occur in sports, falls (particularly from cliffs, or in mountains) or any road crash event.

Most friction burns can be treated by skin-grafting, but some require flaps.

50.19 Reconstruction

SIMPLE TECHNIQUES
You can excisie the scar tissue and replace it with either a skin graft or a local flap. The former is particularly useful for relatively wide scars or if there is scar tissue is over a whole limb with joint contractures.

Make incisions away from the joint itself otherwise you will end up exposing the joint itself and its tendons. For a flexion deformity, make one incision above the joint and another below. Incise down though all the scar tissue, which often includes the underlying fascia.

Remember postop to splint the joint in extension until the graft is fully healed and then encourage movement but advise wearing the splint at night for at least 6months.

You may be able to release and perform a Z- plasty; this is a useful way of releasing a contracture, if it is narrow enough. It is not an easy method, but if your result is not perfect, you can always graft any bare areas that remain.

Unfortunately, most burns usually cause scarring in all directions, so that there is no lax tissue at either side, and a Z–plasty is unsuitable. But in those burns where it is suitable, it is very effective.

Place the long limb of the Z in line with the contracture and then make two further incisions at c. 60^0 angle to the main limbs of the Z. This creates 2 triangular flaps which you can raise and transpose to create lengthening.

Details are in volume 1: 34.2