Escharotomy and Decompressive Therapies in Burns

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Experienced clinicians treating burns recognize the need for escharotomy and decompressive therapies. The burning process causes the integument to become stiff, and the underlying tissues can swell during the fluid resuscitation process. We reviewed the literature that supports the current clinical practice of decompressive therapies following burn injury. (J Burn Care Res 2009;30:759–768)

RECOMMENDATIONS

Standards

This is an update of the excellent review published by Saffle in 2001.[1] Since that time, the indications for escharotomy have not substantially changed; but there is a greater understanding of the broader role of decompressive therapies in burn care, which are included. More recently, escharotomy has been classified as part of a larger class of decompressive therapies including fasciotomies, nerve releases, orbital releases, and decompressive laparotomies. There are insufficient data to support a treatment standard for escharotomies and decompressive therapies.

Guidelines

Each guideline will be followed by the Grade of Recommendation as described by the Oxford Center for Evidence-Based Medicine (http://www.cebm.net/) (Table 1).

1. Extremities or the anterior trunk that have circumferential or near circumferential burns may develop ischemia from increased compartment pressures caused by fluid resuscitation within a nondistensible eschar. Escharotomies are performed as a releasing skin incision allowing the subcutaneous tissues to be decompressed. Grade of Recommendation-B.
2. Absence of Doppler pulses is an indication for escharotomy. The presence of Doppler pulses does not necessarily indicate adequate perfusion. Grade of Recommendation-B.
3. Compartment pressures can be measured and escharotomy should be performed for pressures >40 mm Hg and considered for those >25 mm Hg. Grade of Recommendation-B.
4. Escharotomy incisions are made in a longitudinal fashion through the burned skin avoiding underlying neurovascular structures. If recovery of blood flow is not obtained in the extremities, additional opposing longitudinal incisions are made. Escharotomies of digits and neck remains controversial. Grade of Recommendation-B.
5. Burns in conjunction with other trauma such as electrical or crush injuries, may require other decompressive therapies such as fasciotomies or nerve releases. It is unusual for a thermal burn to require a fasciotomy. Grade of Recommendation - B.
6. Escharotomies of the chest may help relieve respiratory and hemodynamic dysfunctions. Grade of Recommendation-B.
7. Intra-abdominal hypertension can lead to abdominal compartment syndrome (ACS), either in the presence of abdominal eschar or as the result of large volume resuscitation in the absence of significant abdominal burn. Decompression with an intra-abdominal decompression catheter or decompressive laparotomy can be considered. Grade of Recommendation-C.
8. Measurement of intraocular pressure should occur for burns in the region of the eye or in the presence of increased edema from fluid resuscitation and decompressive therapies including a lateral canthotomy may need to be performed. Grade of Recommendation-C.

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Table 1. Grades of evidence (Oxford Centre for Evidence-Based Medicine)

Grades of recommendation	
A	Consistent level 1 studies
B	Consistent level 2 or 3 studies or extrapolations from level 1 studies
C	Level 4 studies or extrapolations from level 2 or 3 studies
D	Level 5 evidence or troublingly inconsistent or inconclusive studies of any level

Options

1. Consultation or transfer to a center specializing in burn injuries is advised if the need for escharotomy is suspected.
2. Ideally, medical personnel that are trained and credentialed should perform escharotomies. To avoid injury, knowledge of the anatomy of underlying structures including tendons, nerves, and blood vessels is essential.
3. Although noninvasive objective methods of assessing distal blood flow in an extremity such as pulse oximetry and Doppler probes may be useful in monitoring extremities, these objective measurement devices may not completely rule out elevated compartment pressures.
4. Prophylactic escharotomies may be warranted in obvious full-thickness circumferential injuries.
5. Burn patients with pulmonary or hemodynamic compromise should be considered for chest and/or abdominal escharotomy.
6. Decompressive therapies should be considered for signs and symptoms of nerve compression including loss of sensation, loss of motor function, or paresthesias.
7. If an adequate abdominal escharotomy has been performed and the patient has symptoms of ACS, such as decreased urine output, hemodynamic instability, and difficulty with ventilation, measurement of intra-abdominal pressures may be indicated. For measurements >25 mm Hg, a decompressive laparotomy or placement of an intra-abdominal fluid removal catheter should be considered.

OVERVIEW

Purpose

The purpose of this guideline is to review the current clinical practice of identifying signs of compartmental compression or tissue ischemia in the burned patient and reviewing the level of evidence that supports current protocols of performing escharotomies or other decompressive therapies for relief of elevated tissue pressure.

Users

This guideline is meant to be referenced by physicians and other health care providers who are responsible for the initial and follow-up care of burned patients.

Clinical Problem

Full-thickness circumferential burns of the extremity result in an eschar that is noncompliant, demonstrating mechanical properties similar to leather. During the fluid resuscitation phase of burn care, fluids accumulate in the extracellular space via transcapillary fluid efflux. Generally, this occurs slowly over time, and so it is rare that escharotomy will need to be performed within the first 4 to 6 hours after injury. Because of the noncompliance of the circumferential eschar, pressure within the compartment increases and may eventually lead to ischemia and necrosis of tissues within the compartment. If untreated, the end result can be amputation, tissue loss, infection, or a painful muscle contracture. In the chest and abdomen, large areas of burn can prevent the natural expansion of skin during respiration. Without release, hemodynamic or respiratory compromise can result. Burns around the eye may result in elevated intraocular pressures either due to constriction or swelling from fluid resuscitation. Unfortunately, there are no objective tests that have been proven to unambiguously predict the need for escharotomy and other decompressive procedures, which carry substantial morbidity. Escharotomies should not be performed on the basis of the burn lesion alone. Decreased or absent oximetry or Doppler probe signal, increased compartment pressures, and sudden onset of neurological symptoms are common reasons given to perform an escharotomy. The overall decision on whether to perform an escharotomy is ultimately based on experience and overall clinical judgment.

PROCESS

Medline™ 1966 to 2008 was reviewed for "escharotomy" and "decompressive therapies" as well as published works on escharotomy and decompressive therapies related to burns. Each article, along with several references within the articles, was evaluated according to the Oxford level of evidence (http://www.cebm.net/levels_of_evidence.asp). Articles are summarized with their levels of evidence in Table 2.

Table 2. Evidentiary table

	Reference	Description of Study	Data Class	Conclusions/Remarks
Escharotomy	Edstrom et al[9]	Prospective, randomized study on 222 hand burns to compare late (after 14 d) excision and skin grafting and conservative treatment	1b	There was no difference between groups when range of motion exercises, accurate splinting, and pressure were used
	Bardakjian et al[16]	Ischemia was assessed by means of pulse oximetry in circumferentially burned extremities (26 limbs in 15 patients). For O_2 saturations <95%, 2 patients (4 limbs) had escharotomies with subsequent restoration of O_2 saturations. These limbs also had absent pulses and motor/sensory abnormalities that were reversed)	2b	When saturation <95%, authors advocate escharotomy (comment: clinicians should verify that systemic saturation is normal before performing escharotomy because many factors can influence oxygen saturation)
	Clayton et al[7]	In 27 circumferentially burned extremities in 12 patients, clinical signs, muscle blood flow (MBF; ^{133}Xe washout) and Doppler pulses were compared. MBF improved from subnormal levels with escharotomy. There are no cases of tissue ischemia with MBF > 1.50 ml/min/100 g	2b	Sequential measurements are necessary to determine need for escharotomy (comment: ^{133}Xe washout is not commonly performed today)
	Moylan et al[6]	Prospective evaluation of circulatory changes in 60 limbs in 24 patients with circumferential burns using ultrasonic flowmeter. Clinical evidence of inadequate circulation that was seen in one-half of extremities had normal Doppler flow and was successfully managed non-operatively with elevation and exercise. In patients undergoing escharotomy flow was restored flow and clinical signs reversed	2b	Absence of Doppler flow in distal arteries or arches is an indication for escharotomy (comment: despite clinical evidence of tissue compression and ischemia, this article also shows that Doppler pulses can be present. Postponing escharotomy until pulses are lost is potentially dangerous)
	Oda et al[36]	Eight patients with 70–99% TBSA burns with elevated bladder pressures and who had abdominal escharotomies were studied. In all cases, physiological parameters including bladder pressures, peak inspiratory pressure, and urine output improved	2b	Patients with large TBSA burns with increased abdominal pressures improve physiologically with decompressive abdominal escharotomies
	Picollo et al[20]	Series of 58 patients with circumferential burns of the extremities were treated according to an algorithm using oximetry and clinical signs for surgical decision making as to when to perform a decompressive operation	2b	Use of an algorithm with a focus on peripheral circulation monitoring provides a means for expedient decisions and a lesser chance of tissue damage after a burn
	Russell et al[12]	Muscle blood flow (MBF) in 20 normal volunteers and 13 burn patients was measured using the ^{133}Xe washout technique. Burn patients had MBF levels above normal, but decreased to below normal in presence of tight, circumferential escharotomy. After escharotomy, this reverted to normal	2b	Normal muscle blood flow can be restored with escharotomy
	Saffle et al[13]	Intramuscular pressure (IMP) was measured with a Wick catheter in 31 extremities compared with clinical and Doppler findings. A threshold for escharotomies was when IMP ≥30 mm Hg, or absent pulses. Of 13 limbs, only 3 with elevated IMP ≥30 mm Hg had absent pulses. Treatment randomized to IMP >30 mm Hg or absent pulses in 8 patients with bilateral burns. Prolonged recovery was observed in three patients with intact pulses and elevated IMP who did not undergo escharotomy	2b	Advise routine measurement of IMP because they are more precise than Doppler pulses and use a threshold value of 30 mm Hg for implementing escharotomy

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Table 2. (*Continued*)

Reference	Description of Study	Data Class	Conclusions/Remarks
Salisbury et al[10]	After extremity burns, postmortem intrinsic muscle biopsies were evaluated. Rate of necrosis was similar in patients with (72.2%) and without (66%) escharotomies	2b	Even with intact pulses and implementation of escharotomy, muscle ischemia/necrosis can occur (comment: tissue necrosis may have been a nonspecific consequence of a postmortem study)
Salisbury et al[21]	Prospective, comparative study assessing the addition of digital escharotomies to limb escharotomies in circumferential upper extremity burns with absent flow in peripheral vessels/arch. After digital escharotomies, digital necrosis decreased (7% vs 21%)	2b	In circumferential hand burns digital escharotomies are recommended (comment: measurement of tissue pressure in digits is impractical and many burn surgeons do not perform finger escharotomies unless burns are deeply circumferentiated)
Tsoutsos et al[26]	Bladder pressure and gastric pressure were measured in 10 burn patients >35% TBSA. All patients had elevated intra-abdominal pressure. Immediate improvement of all the parameters was documented and after abdominal escharotomy	2b	Escharotomy is an efficient way to relieve elevated intra-abdominal pressure
Demling et al[22]	Review of clinical experiences and physiologic changes of circumferential chest burns (compared with body burns) in 10 patients with escharotomy. Hemodynamic and pulmonary abnormalities were not reversed but improved with escharotomy	3a	In circumferential chest burns with physiologic abnormalities, chest escharotomy should be considered
Pruitt et al[5]	Retrospective study documenting experience in 55 patients with 125 escharotomies with circumferential burns without complications. Consequences of deferring escharotomy are described	3a	When escharotomy was not performed in circumferential burns, significant morbidity (3 amputations) ensued
Kaplan and White[3]	Circumferential lower extremity burns were documented in 6 patients with lower extremity burns. In 3 cases where escharotomy was deferred or delayed a permanent deformity or amputation resulted	3b	Distal ischemia can be reversed/prevented with longitudinal releasing incisions to bleeding tissue in deep circumferential burns
Meade[4]	Clinical improvement after longitudinal escharotomies of extremities (2) and chest (1) with no improvement with transverse incisions (1) was detailed in two case reports	3b	Ischemia can be reversed/prevented by means of longitudinal releasing incisions
Smith et al[11]	Vascular status in burned extremities, determined by prospective evaluation of infrared photoplethysmography (PPG), was compared with IMP, Doppler, and MBF. PPG correlated positively with MBF and IMP but poorly with Doppler with variations noted with IMP > 30 mm Hg	3b	PPG can be used to non-invasively assess vascular status (comment: PPG not available in most centers)
Bennett and Lewis[2]	Two case reports of circumferential extremity burns displaying vascular compromise with improvement and restoration of blood flow by dye injection	4	In constricting circumferential burns, flow can be reestablished by escharotomy

(*Continued*)

Table 2. (*Continued*)

	Reference	Description of Study	Data Class	Conclusions/Remarks
Other decompressive therapies	Greenhalgh and Wardenv[33]	Prospective study on 30 burned children with large burns and elevated intra-abdominal pressure	2b	Significant elevations in intra-abdominal pressure are seen in large burns and carry a poor prognosis
	Latenser et al[37]	Studied 9 patients with severe burns that developed ACS and were initially treated with peritoneal dialysis (PD) catheter. Four patients continued to have ACS and had further decompressive laparotomy with 100% mortality	2b	PD catheter may be a reasonable way to treat intra-abdominal hypertension (IAH)/ACS in large TBSA burns
	Parsak et al[32]	A prospective nonrandomized study in 190 nonburn patients showing 36% mortality with ACS	2b	ACS has a high mortality and may be improved by decompressive laparotomy
	Singh et al[23]	Studied 8 patients with large burns who underwent intraocular decompression with reduction of intraocular pressures	2b	Intraocular pressures can be reduced by decompressive procedures in large TBSA burns
	Burd et al[24]	Indexed, library, and web-based information sources and a review of patients transferred to a regional burn unit support the need for improved teaching of decompression therapies. Patients (37%) had not been decompressed before transfer	3a	Should perform decompressive therapy including fasciotomies when needed
	De Waele et al[30]	Reviewed 18 studies and 250 patients with IAH/ACS	3a	IAP remains lower after decompressive procedures, mortality remains high
	Engrav et al[28]	Based on survey of ~10% of the American Burn Association, 80 patients with electrical injuries were reviewed. Five patients (8 extremities) did not require amputation and exhibited immediate palsy of the median and ulnar nerves at the wrist	3a	Nerve palsies were shown to recuperate significantly (comment: the authors recommend nerve decompression understanding that this is not proven in the literature)
	Hershenberger et al[35]	Retrospective review of 25 patients who underwent decompressive laparotomy for ACS using the IVY score, bladder pressure, and peak inspiratory pressure as a guide for surgery	3a	Measure bladder pressures hourly if Ivy score >200 ml/kg and perform decompressive laparotomies on all patients with ACS if other less invasive measures fail
	Mann et al[27]	Retrospective review of 62 patient charts documenting upper extremity contact with >1000 V of electricity. One hundred upper extremities were treated, 22% decompressed within 24 hours due to progressive nerve dysfunction, clinical compartment syndrome, or failure of resuscitation. This group required a mean of 4.2 operations with 45% amputations and a 27-d hospital stay	3a	The injury itself influences the need for amputation and multiple operations. Immediate decompression is only necessary for usual clinical signs of compartment syndrome. Tissue may be preserved and applying selective decompression decreases the need for eventual amputation
	Ivy et al[34]	Report of 3 adults with TBSA >70%, requiring more than 20 L of crystalloid resuscitation who developed ACS. 100% mortality rate. In the authors' institution, intra-abdominal pressure is now routinely measured as part of the burn resuscitation process in an attempt to diagnose and treat this syndrome earlier	4	The authors suggest considering ACS when diagnosing any patient with burns who develops high airway pressures, oliguria, or both

(*Continued*)

Table 2. (*Continued*)

Reference	Description of Study	Data Class	Conclusions/Remarks
Justis et al[40]	Four patients with lower extremity compartment syndrome	4	Early fasciotomy may prevent this complication
Li et al[39]	Five patients with lower extremity compartment syndrome	4	Early escharotomy and/or fasciotomy may prevent complications
Smith et al[29]	Three patients sustained low-voltage electrical injury with peripheral nerve symptoms without clinically significant cutaneous burns. Surgical nerve decompression was used to treat symptomatic nerves. Perineurial fibrosis was documented at the time of nerve decompression	4	Electrical injury can lead to nerve injury because of Joule heating

SCIENTIFIC FOUNDATION

Early clinical descriptions of circumferential burns are similar in symptoms to other signs of vascular compromise and include the five "P's": pallor, pulselessness, paralysis, paresthesias, and pain. The burned skin is released by longitudinal incisions through the skin.[1–4] Because of the mechanical stiffening that occurs with a full-thickness burn, swelling beneath the burn as a result of fluid resuscitation can lead to increased pressure within the tissues.

Determining factors for performing escharotomies have evolved from nonspecific clinical signs alone (digital cyanosis, lack or impairment of capillary refill in the nail bed or distal finger skin, pain on passive motion, and even neurological changes) using the Doppler flow meter to identify blood flow.[5–8]

Poor oxygenation in the tissues as measured by Doppler or oximetry in the index finger is a factor discussed by Edstrom et al[9] in a prospective randomized trial. The index finger usually has digital arteries of both radial and ulnar in origin suggesting that blood flow in this finger may be indicative of perfusion to all vascular structures in the hand. However, in deep burns, some recommend that all fingers must be evaluated to determine individual escharotomies (Figures 1 and 2). Escharotomies can also be performed on the foot at the web spaces or on the second toe if necessary.[9]

Pruitt et al[5] performed a retrospective review in 125 patients and noted that longitudinal incisions through eschar could reduce the symptoms of tissue loss. Because of the gratifying effect of escharotomy on restoring blood flow, it is highly unlikely that a

Figure 1. Incisions for hand escharotomy showing dorsal incisions over the first and fourth proximal metacarpals and finger escharotomy incisions. Radial sides of the fourth and fifth finger are incised. Reproduced with permission from Handchir Mikrochir Plast Chir 2007;39:161–7.

Figure 2. Ulnar side of the second and third fingers are incised first to minimize nerve damage to pinch surfaces. Reproduced with permission from Handchir Mikrochir Plast Chir 2007;39:161–7.

prospective randomized controlled clinical study will ever be performed to obtain high level of evidence for this procedure.

Investigators have studied objective methods to measure perfusion within the extremities. Moylan et al[6] described the use of ultrasound or Doppler flow meter to assess distal blood flow in palmar or pedal vessels. This technique also allows the pulse status to be followed after escharotomy to help assess the adequacy of release. Salisbury et al[10] demonstrated that despite Doppler signals being present, muscle ischemia could still occur in the intrinsic musculature and can lead to hand dysfunction. Also, it has been observed that Doppler flow meter evaluations can be misleading when abnormal flow signals are present distal to an obstruction, which may incorrectly establish flow at the site.[5–8] Doppler pulses, provide a less invasive, simpler method of evaluating the extremity and do not necessarily correlate well with muscle blood flow and intramuscular pressure.[11]

Other methods have been described but are often impractical because of the critical nature of these patients. Muscle blood flow has been evaluated using a 133Xe-washout technique that shows high sensitivity but is impractical to use in critically ill patients in burn centers.[12] Saffle et al[13] used a wick-catheter technique, as described in compartment syndromes, to evaluate circumferentially burned limbs. Using a recommended threshold value of 30 mm Hg from the compartment syndrome literature on which to base the need for escharotomy, the authors observed a dramatic fall in intramuscular pressures after escharotomy and no instances of long-term morbidity. In a randomized group of eight patients with bilateral burns, either absent Doppler pulses or intramuscular pressure >30 mm Hg was used as a criterion for performing escharotomy. Three limbs with elevated pressures by intact Doppler pulses were not released and demonstrated prolonged recovery.

Small, uncontrolled series have used infrared photoplethysmography (PPG to measure blood volume changes in the microvasculature. Bendick et al[14] reported the use of infrared light for determining the efficacy of blood flow in extremities with circumferential third-degree burns. PPG had also been compared with measurements with the Doppler flow meter and Xe133 in normal volunteers with good correlation.[11]

Pulse oximetry is a common sensitive tool that quickly detects hypoxia.[15] Transmission pulse oximetry has also been used for the evaluation of circumferentially burned extremities and intramuscular pressure. Because it is most commonly used on digits, the signal is affected by vasoconstriction. Pulse oximetry is easy to use, either with disposable or resterilized sensors, in the very small or in the very large patient, through healthy skin or even through a burnt nail bed, with or without the nail. Although initially some authors recommended immediate escharotomy when oxygen saturation fell below 95%, a 90% level is a more practical threshold. Maintaining a 6% difference between a healthy site and the injured site is indicative of impeding.[16–20]

Using an oxygen saturation level of 95% as a threshold value, Bardakjian et al[16] reported no long-term clinical evidence of tissue ischemia above this value and described a return to normal values after escharotomy when an oxygen saturation of <95% was observed. The use of PPG and pulse oximetry assume that the burn injury to the digits themselves is not severe enough to preclude these methodologies.

There is a lack of studies evaluating escharotomies in clinical circumstances other than circumferentially burned extremities. Salisbury et al[21] prospectively evaluated the use of digital escharotomies in addition to standard limb escharotomies. Although the sample size was small, there was a reduced incidence of digital necrosis (7.5 vs 20.8%) in those patients with digital escharotomies. A number of authors have advocated chest escharotomies, but only one report documents an improvement in objective physiologic parameters following this procedure.[22] Escharotomies of the neck and penis have also been described and should be considered.[6] Burns around the eye should be evaluated for increased intraocular pressure and a decompressive procedure including skin release and possible lateral canthotomy performed. Singh et al[23] reviewed eight patients in their institution that had decompressive procedures performed with a mean intraocular pressure of 59 mm Hg. Because there are no large series of cases, the decision to do these procedures is based on clinical judgment and experience.

Recent studies are now pointing to escharotomy as part of a larger class of decompressive procedures used by surgeons to maintain adequate perfusion to tissues and vital organs.[24–26] These procedures include fasciotomies, peripheral nerve releases, ocular releases, and decompressive procedures for intraabdominal hypertension. Burd et al[24] points out that escharotomy is a limited procedure that needs to be part of an overall continuing assessment of decompressive therapies as the patient goes through the various phases of burn treatment.

For electrical burns, the need for decompression has not been proven although most surgeons will tend to decompress the carpel tunnel and Guyan's canal for symptoms of nerve decompression.[27,28] Smith et al[29] reported three cases of peripheral compression without skin involvement after low-voltage electrical injury.

Increases in intra-abdominal pressure can lead to ACS and subsequent pulmonary and renal dysfunctions. Decompressive laparotomy has become accepted in the trauma literature as a means to address ACS. Although intra-abdominal pressure is decreased after decompression and often urine output increases, mortality has still been described between 49 and 100% in patients who develop ACS.[30–32] Greenhalgh and Warden[33] prospectively studied 30 children with large burns and measured intra-abdominal pressure ever 4 hours. Patients with pressures >30 mm Hg were those with the larger burns, were more likely to develop sepsis, and had a much poorer prognosis. In 1999, Ivy et al[31] described three elderly patients with >70% burns who developed ACS and died. As a result of his observations, he developed the Ivy Score to guide monitoring and intervention in ACS.[34] The Ivy Score correlates cumulative resuscitation volumes (in milliliter per kilogram) with maximum abdominal pressure. When the Ivy Score is >250 ml/kg or the PIP is >40 cm H_2O, bladder pressure should be monitored every 2 hours. Hershenberger et al[35] reviewed 25 burned patients with a diagnosis ACS after resuscitation, who underwent decompression laparotomy and reported a mortality of 88%. On the basis of their observations, they developed clinical practice guidelines for burn patients with >20% TBSA and inhalation injury or isolated >40% TBSA, which include calculating an Ivy Score on admission, monitoring urine output every 30 minutes with a goal of 0.5 to 1 ml/kg/hr, measuring bladder pressure and abdominal perfusion pressure every 4 hours or more frequently if bladder pressure equals or exceeds 15 mm Hg, and reassessing sedation and paralysis frequently. Oda et al[36] reviewed 8 patients who underwent abdominal decompression following large TBSA burns and found improvement in hemodynamics after decompression. To avoid the potential complications of an open abdomen in a large burn patient, Latenser et al[37] proposes first using a paracentesis catheter.

In the past, it has been suggested that mandatory diagnostic fasciotomies be used to evaluate muscle tissue in electrical burns or suspected compartment syndrome cases. However, the evaluation of neural symptoms, with progression of neurological signs, pain on stretching muscles of the suspected compartments, and abnormal pressure measurements, is diagnostic and can also guide surgical decisions. Pressure measurements are the desired method for deciding when to surgically release a muscle compartment but even in facilities where these monitoring abilities would be easily available, clinical symptoms decide

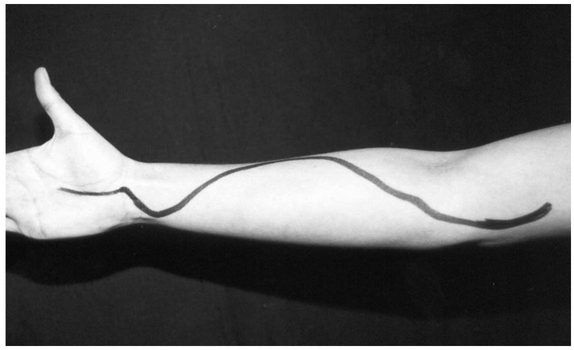

Figure 3. Incision marking for an upper extremity fasciotomy for access to the volar and posterior compartment fasciae. Incision line can be extended distally for a carpal tunnel release, proximally through the medial forearm, and anteriorly to the medial epicondile, thus avoiding the ulnar nerve. Reproduced with permission from Handchir Mikrochir Plast Chir 2007;39:161–7.

the procedure in up to 75% of the cases. Forearm fasciotomies extending into the hand using a carpel tunnel release are shown in Figure 3. Fasciotomies may also be performed for diagnostic purposes such as accessing deeper tissues, evaluating the condition of the underlying muscles with direct observation and determining the extent of muscle necrosis. If necrotic muscle tissues are unnoticed, putrefaction may lead to abscesses and possibly sepsis. This may occur in several different situations, such as multiple trauma patients, severe exertional, and compressive stress or crush injuries. Muscle necrosis can also occur subacutely in burn patients because of high-volume resuscitation, delayed escharotomy, extravasated intraosseous infusion, cannulation-related arterial injury through a possible reperfusion phenomenon, external pressure from poorly applied splints, or even malpositioning of the patient while sedated in the intensive care unit or under anesthesia. The burn surgeon will often encounter other pathologies where fasciotomy will be performed for diagnostic and treatment purposes, such as in multiple trauma patients or purpura fulminans cases, with intracompartmental pressures being reported >50 to 60mm Hg.[38]

SUMMARY

Many burn surgeons recognize the need for decompressive therapies, including escharotomies, when pulses are absent in the extremities with circumferential burns and when respiration is impaired with chest and abdominal burns. Without decompression, tissue damage including muscle necrosis and peripheral nerve dysfunction can occur. Muscle necrosis can lead to myoglobinemia resulting in renal dysfunction. There have not been, nor will there likely to be, any large prospective randomized trials to provide level I evidence to justify these practices, but decompression therapy has become the standard of care in burn units throughout the world. Noninvasive or minimally invasive monitoring methods have been described to more objectively guide therapies including compartment pressure measurements and Doppler measurements. Although not all burn units use the above monitoring techniques to guide treatment, there is good evidence in the literature that compartment pressures >40 mm Hg will lead to tissue ischemia and levels for 25 to 40 mm Hg may result in tissue damage. Some authors recommended immediate escharotomy when oxygen saturations from pulse oxymetry falls below 95%, and others use a 90% as a threshold.

Caution should be used when interpreting pulse oximeter readings in patients with vasoconstriction, because low readings may not be due to the eschar. Escharotomy can cause significant morbidity, and generally, is not needed until several hours into the burn resuscitation. Therefore, in most cases, it can be delayed until the patient is transferred to a burn center familiar with performing these procedures. After the escharotomy is performed, continued monitoring is necessary, because the incisions may need to be extended. Clearly, escharotomy is not a totally benign procedure and if not indicated or if improperly performed, can result in unnecessary trauma, peripheral nerve damage, tendon injury, and blood loss. As new strategies emerge to reduce the fluids given on resuscitation, the need for escharotomy may be reduced in certain circumstances. Other decompressive therapies such as fasciotomies, nerve releases, ocular releases, and decompressive laparotomies also need to be considered in burn patients particularly those with electrical and fourth-degree burns.

KEY ISSUES FOR FURTHER INVESTIGATION

1. Development of more sensitive clinical tools or bedside technology to diagnose tissue ischemia earlier, before rhabdomyolysis has evolved.
2. Determination of threshold values for muscle and nerve ischemia.
3. Determination of the biomechanical properties of eschar and modeling tissue pressure and release criteria.
4. Comparing prophylactic escharotomy vs escharotomy performed based on objective measurements.
5. Additional hemodynamic and respiratory studies for patients undergoing chest and abdominal escharotomies.

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