110 Extremity Compartment Syndrome

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110.1 Introduction

Learning Goals
- Identify patients at risk for extremity CS.
- Learn the early and late signs of CS and how to perform the appropriate investigations for definitive diagnosis.
- Familiarity with the anatomy of the extremity muscle compartments and the technique of a decompressive fasciotomy.

110.1.1 Epidemiology

Young males are at a higher risk for extremity CS due to their increased muscle mass. After extremity trauma, approximately 1% of patients require fasciotomy. The incidence of CS requiring fasciotomy varies widely by the mechanism and type of injury, reaching up to 42% in patients who sustained a combined arterial and venous injury [1]. The lower leg is the most common site for compartment syndrome, followed by the forearm, thigh, arm, foot, and buttocks, in this order [2–6].

110.1.2 Etiology

Extremity CS is most common after severe trauma, with approximately 75% of cases associated with long bone fractures. The most common fractures causing limb compartment syndrome are tibial shaft (40%) and forearm (18%) fractures [7]. Other common etiologies include vascular injuries, particularly combined arterial and venous injuries, soft tissue crush injuries, and circumferential burns [8]. Iatrogenic causes include external compression by tight bandages or casts, accidental extravasation of fluids in the soft tissues, and excessive crystalloid fluid resuscitation. In rare occasions, prolonged general anesthesia in morbidly obese patients may cause compartment syndrome in the buttocks. Prolonged extremity compression in unconscious patients, often after narcotic overdose or alcohol intoxication, is another cause of CS observed with increasing frequency. In rare cases, excessive physical exercise, such as long-distance running, particularly by untrained people, may cause CS. Medical conditions such as bleeding diathesis or pharma-

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Table 110.1 Risk factors for compartment syndrome

SEVERE TRAUMA
Long bone fractures
Injury to vascular structures
Crush injury
SPONTANEOUS HEMORRHAGE, HEMATOMA
Hereditary bleeding disorder
Pharmacological anticoagulation
EDEMA - INCREASED PERMEABILITY
Circumferential burns
Accidental fluid extravasation in soft tissue, excessive crystalloid fluid resuscitation
SIRS
Others: thrombosis, tourniquet use
OTHERS
External compression by splints or casts, myositis, rhabdomyolysis, soft tissue infection, excessive physical exercise

cological anticoagulation may cause spontaneous bleeding in a muscle compartment and result in CS. Common risk factors for extremity CS are summarized in Table 110.1.

110.1.3 Classification

Extremity compartment syndromes can be separated into acute and chronic [9]. The present chapter focuses on acute extremity CS. Chronic extremity compartment syndrome is characterized by a recurrent exercise-induced increase in compartment pressure with transient neurologic symptoms and pain. Typically, the symptoms resolve with rest.

CS can be classified as primary (direct limb-related injury) and secondary (non-limb-related injury), such as after massive crystalloid fluid resuscitation [10]. Alternatively, extremity CS is divided into early, when tissue pressure elevation lasts for less than 4 h, and late, if it lasts for more than 4 h [11]. Ischemia lasting longer than 4–6 h causes irreversible damage to the muscles and nerves.

110.1.4 Pathophysiology

The normal muscle compartment pressure is less than 8 mmHg. Increase in pressure to >20–25 mmHg results in tissue perfusion impairment, and at >30–40 mmHg, the ischemia is considered critical and an emergency fasciotomy should be considered. An alternative to the absolute compartment pressure is the perfusion pressure (diastolic pressure minus the compartment pressure). A perfusion pressure of <30 mmHg indicates severe tissue hypoperfusion and is considered an indication of an emergency fasciotomy [12].

Nerve ischemia lasting for more than 4 h and muscle ischemia for more than 6 h can cause irreversible damage, and for this reason, early intervention is essential [13–15]. Depending on the severity and duration of the ischemia, the patient may develop true muscle necrosis, chronic muscle contracture, sensory deficit, paralysis, and, in severe cases, loss of limb. Volkmann contracture in the upper extremity and foot drop in the lower extremity are specific clinical patterns for this terminal state.

In addition to local complications, the ischemic muscle damage causes myoglobinemia and myoglobinuria, which can result in acute kidney injury. Myoglobin has a direct toxic effect on the renal tubular epithelium and can cause tubular occlusion due to precipitation. Myoglobin levels are rarely measured, and a common practice is the measurement of creatine phosphokinase (CPK) levels. CPK levels >5000 units/L in adults, especially in elderly or severely injured patients, and >3000 units/L in children, were found to be an independent risk factor for acute kidney injury [16, 17]. Young males are significantly more likely to have CPK levels >5000 units/L because of the greater muscle mass in this group. Other laboratory changes include hyperkalemia and hypocalcemia, which are a potentially dangerous cardiotoxic combination.

110.1.5 Surgical Anatomy

Extremity fascial compartments contain muscles, nerves, and blood vessels.

Upper Extremity

The upper extremity fascial compartments include two in the upper arm, three in the forearm, and ten in the hand.

- The upper arm contains a relatively large anterior and posterior compartment, separated medially by the brachial artery and median nerve. The anterior compartment contains the biceps, the brachialis and coracobrachialis, and the musculocutaneous nerve. The posterior compartment contains the triceps and the radial nerve.
- The forearm is separated into three muscle compartments: the anterior or flexor compartment, which contains the muscles responsible for wrist flexion and pronation of the forearm. These muscles are innervated by the median and ulnar nerves and receive blood supply mainly from the ulnar artery. The posterior or extensor compartment, which contains the muscles responsible for wrist extension, is innervated by the radial nerve, and the blood supply is provided mainly by the radial artery. The mobile wad is a group of three muscles on the radial aspect of the forearm that act as flexors at the elbow joint. These muscles are often grouped together with the dorsal compartment. The blood supply is provided by the radial artery and the innervation by branches of the radial nerve.
- The hand includes ten separate osteofascial compartments. The transverse carpal ligament, over the carpal tunnel, is a strong and broad ligament. The tunnel contains the median nerve and the finger flexor tendons.

Lower Extremity

The lower extremity fascial compartments include three gluteal, three thigh, four calf, and nine of the foot.

- The buttock includes the muscle compartments of the gluteus maximus, the gluteus medius/minimus, and the extension of the fascia lata of the thigh into the gluteal region. The sciatic nerve is the only major neurovascular structure in the compartments of the buttock.
- The thigh consists of three compartments. The anterior compartment contains the quadriceps femoris and sartorius muscles, as well as the femoral vessels and femoral nerve. The posterior compartment contains the biceps femoris, semitendinosus, and semimembranosus muscles, as well as the sciatic nerve. The medial compartment contains the adductor muscle group and the gracilis muscle.
- The lower leg has four compartments: the anterior, lateral, superficial posterior and deep posterior. The anterior and lateral compartments are the most common sites of extremity compartment syndrome. The anterior compartment contains the anterior tibial artery and the deep peroneal nerve. The lateral compartment contains the superficial peroneal nerve. The superficial posterior compartment contains the sural nerve. The deep posterior compartment contains the posterior tibial artery and the tibial nerve.
- The foot contains a total of nine muscle compartments.

110.2 Diagnosis

The diagnosis of CS is based on a combination of clinical examination, CPK level, and direct measurement of compartment pressures.

110.2.1 Clinical Presentation

The diagnosis of extremity CS requires a high index of suspicion combined with knowledge of the underlying risk factors. The “six Ps” (pain, paresthesia, pallor, poikilothermia, pulselessness, and paralysis) are signs and symptoms classically described in the extremity CS. Pain out of proportion, often not responding to analgesia, is the most common and earliest clinical finding. Usually, pain can be exacerbated by a passive stretch of the involved muscle. Another relatively early sign is paresthesia, which indicates hypoxia in nerve tissue within a compartment. Altered sensation between the first and second toe, for example, could indicate a deep peroneal nerve ischemia from an anterior compartment syndrome of the lower leg. The involved compartment often feels tense to palpation. However, this finding is operator-dependent and often lacks reproducibility. Pulselessness, pallor, and paralysis are late symptoms, and in their presence, the prognosis is often poor.

Overall, the positive predictive value of the clinical findings is low, and the specificity and negative predictive value are high [18]. These findings suggest that the clinical features of compartment syndrome are more useful in their absence in excluding the diagnosis than they are when present in confirming the diagnosis. Although clinical suspicion is important, the diagnosis of CS in the trauma population is often difficult. Trauma patients are frequently altered or require intubation, sedation, or paralysis, making a reliable and reproducible assessment of the extremity difficult. The diagnosis of extremity CS in very young children is particularly challenging because escalating pain may not be easily identified, and the clinical diagnosis should be based on three As: anxiety, agitation, and increasing analgesic requirement [19].

110.2.2 Investigations

Given the poor positive predictive value of clinical examination and the difficulties inherent in the trauma population, a low threshold to perform direct compartment pressure measurements should be encouraged. Direct measurement of muscle compartment pressures is the most objective test for definitive diagnosis and should always be performed in suspected cases.

There are no specific diagnostic laboratory tests. However, elevated CPK levels in high-risk patients should raise the suspicion of a compartment syndrome. Myoglobinuria can develop within 4 h of the onset of extremity CS. The urine is dark, brownish, or red when viewed macroscopically, but hematuria is absent on microscopic urine analysis.

An abnormal SaO_2 in the affected toes and fingers is a late finding of extremity CS and is not appropriate to detect early stages.

Multiple techniques for direct compartment pressure measurement have been described [20–22]. Direct compartment pressures may be obtained with a variety of commercial devices or using a simple arterial line setup with an 18-gauge needle. It is recommended to measure the pressure in all compartments of the suspected region.

A commonly used commercial device for direct measurement of the compartment pressure is the hand-held Stryker® intracompartmental pressure system. For pressure measurement, the needle is connected to the diaphragm chamber and the diaphragm to the prefilled syringe. The assembled system is then inserted into the opened Stryker device. The flap is closed and the device turned on. The zero button is pressed, and when the display shows zero, the needle is inserted perpendicularly through the skin into the muscle (Fig. 110.1). After a slow injection of 0.3 mL into the compartment and a waiting time of a few seconds to reach equilibrium, the pressure can be read on the display.

In general, a side port needle, as provided with the above device, is more accurate at measuring the compartment pressure, as regular needles may obstruct when entering the soft tissue and falsify the measurement. In the absence of this device, however, an arterial line transducer with an 18-gauge needle can be used with good results, as long as the needle is flushed after introduction into the muscle compartment.

A muscle compartment pressure >30–40 mmHg or a perfusion pressure <30 mmHg is indicative of compartment syndrome and should prompt consideration of decompressive fasciotomy.

110.2.2.1 Instructions for Measurement of the Different Anatomical Compartments

Arm: The arm is kept in a neutral position because flexion or extension at the elbow can affect compartment pressure. The needle is inserted perpendicular to the skin in the middle third of the anterior and the posterior arm, respectively.

Forearm: The forearm is kept in a neutral position before measuring the compartment pressure. For measurement of the pressure in the flexor compartment, the needle is inserted perpendicular to the skin into the middle third of the flexor surface of the forearm. For the dor-

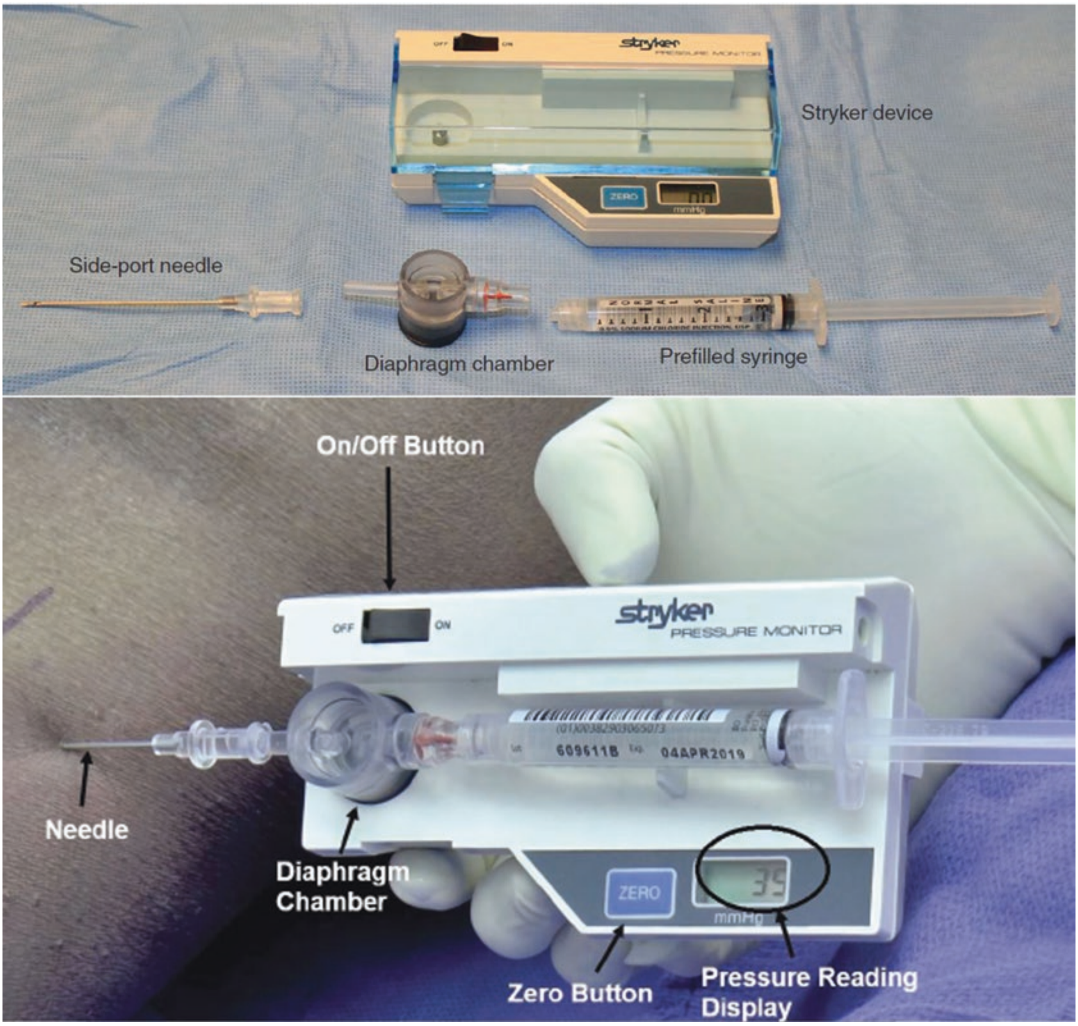

Fig. 110.1 The Stryker system is a commercially available system to measure extremity compartment pressures. It includes the device base, a side-port needle, a prefilled syringe, and a diaphragm chamber (top). (With permission, Atlas of Surgical Techniques in Trauma, eds Demetriades, Inaba, Velmahos, Cambridge University Press, 2015). The assembled system is placed into the Stryker® device and the system turned on. The zero button is pressed, and the system should show “00.” The needle is then inserted perpendicularly through the skin into the muscle. After a slow injection of 0.3 mL into the compartment and a waiting time of a few seconds to reach equilibrium, the pressure can be read on the display (bottom). (With permission, Color Atlas of Emergency Trauma, third edition, eds Demetriades, Chudnofsky, Benjamin, Cambridge University Press, 2021)

sal (extensor), the needle is inserted perpendicular to the skin into the middle third of the extensor surface of the forearm.

Buttock: The compartment pressures in the buttock are best measured with the patient in the prone or lateral position. The needle is inserted into the gluteus maximus, in the lateral upper quadrant, to avoid injury to the sciatic nerve. For measurement of the pressure in the gluteus medius muscle compartment, the needle is inserted deeper.

Thigh: The medial muscle compartment of the thigh rarely develops compartment syndrome. For this reason and because of the risk of vascular injuries, there is no need for routine pressure measurements in this compartment. For anterior compartment pressure measurements of the thigh, the needle is inserted perpendicularly into the skin, in the middle third of the anterior thigh. For posterior compartment pressures of the thigh, the needle is inserted in the middle third of the posterior thigh.

Lower leg: For measurement of the anterior compartment pressure of the lower leg, the needle is inserted perpendicular to the skin approximately two fingerbreadths lateral to the anterior border of the tibia. For the lateral compartment, the entry point is approximately one fingerbreadth anterior to the line joining the head of the fibula and the lateral malleolus. For measurement of the superficial posterior compartment pressure, the needle is inserted in the middle of the calf, at the junction of the upper and middle thirds of the leg. For the deep posterior compartment, the needle is inserted about one fingerbreadth posterior to the medial border of the tibia, at the junction of the upper and middle third of the leg.

Differential Diagnosis

The diagnosis of extremity CS is often delayed or missed, with potentially serious medical and medicolegal implications. In trauma patients, the intractable pain of CS may be incorrectly attributed to the primary injury and the swelling associated with the hematoma around the fracture or in the soft tissues. In patients with major venous ligation and extremity swelling, the differential diagnosis should include deep venous thrombosis and extremity CS.

110.3 Treatment

110.3.1 Medical Treatment

In cases at risk for extremity CS or those with moderately increased compartment pressures, administration of mannitol may reduce the risk of CS and the need for fasciotomy [23]. In these cases, the authors recommend 0.5 g/kg of Mannitol administered over 20 min, provided that the patient is hemodynamically stable. Mannitol is contraindicated in the setting of hemorrhagic shock or hemodynamic instability.

In patients with delayed diagnosis and elevated CPK levels, in addition to decompressive fasciotomy, intensive fluid resuscitation to achieve a minimum urine output of 1 mL/kg/h and maintaining slightly alkaline urine may reduce the risk of acute kidney injury. Administration of mannitol in patients with very high levels of CPK may be beneficial in preventing acute kidney injury.

110.3.2 Surgical Treatment

110.3.2.1 General Operative Principles

Decompressive fasciotomy should be performed emergently in all patients with extremity CS. The role of routine prophylactic fasciotomy in patients at risk for CS is controversial. We do not advocate routine prophylactic fasciotomies if the patient can be monitored closely in a hospital environment because of the local complications associated with the procedure [24]. However, in austere environments where close monitoring is not possible, prophylactic fasciotomies should be considered.

Good anatomic knowledge of the extremity muscle compartments is essential to perform adequate decompression and avoid neurovascular injuries.

The skin incisions should be generous to provide adequate decompression of the muscle compartments. Similarly, all fasciae should be opened along their entire length. The fasciotomy skin incisions should always be left open. All nonviable muscles should be excised because of the risk of necrosis and infection, which may lead to the loss of limb. Muscle not contracting to electrocautery stimulation is not viable and should be removed. The questionably viable muscle may be preserved and reevaluated at a second-look operation. After hemostasis is achieved, the extremity wounds should be dressed with gauze dampened with sterile normal saline with gentle compression for hemostatic purposes. Application of a negative pressure system (VAC) should be avoided at the initial stage because of the increased risk of bleeding. A second-look operation should take place within 24 h of the index operation and perform further muscle debridement, as needed. Negative pressure systems at this stage are recommended because they reduce tissue edema, prevent skin retraction, and facilitate primary skin closure.

110.3.2.2 Upper Extremity Fasciotomy

For the upper arm, the two muscle compartments can be released through a single lateral skin incision, extending from just below the deltoid insertion to the lateral condyle (Fig. 110.2, left). The skin flaps are mobilized anteriorly and posteriorly at the fascial level. The intermuscular septum between the anterior and posterior compartments is identified, and each compartment is incised longitudinally (Fig. 110.2 right).

The forearm compartments can be released with two incisions. A volar incision decompresses the volar compartment and the mobile wad. The dorsal incision decompresses the dorsal compartment. There are various approaches to volar fasciotomy described. We recommend the “lazy S” incision, which should begin 2–3 cm proximal to the antecubital fossa between the biceps and triceps and end along the ulnar edge proximal to the wrist, passing the radial border in the midforearm. The incision is then carried to the midwrist and then curved up onto the hand medial to the thenar eminence (Fig. 110.3). After

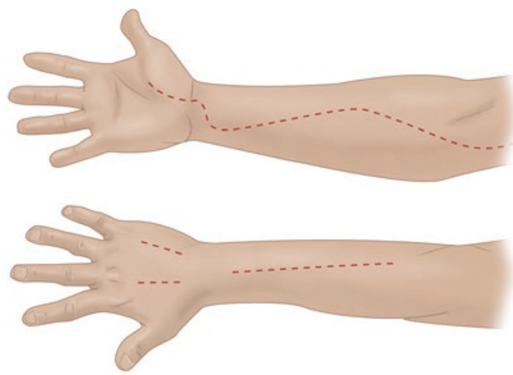

Fig. 110.3 The forearm is decompressed using a serpentine incision on the volar surface crossing the flexor retinaculum, a longitudinal incision on the dorsal surface, and two additional incisions on the dorsal hand. (With permission, Atlas of Surgical Techniques in Trauma, eds Demetriades, Inaba, Velmahos, Cambridge University Press, 2015)

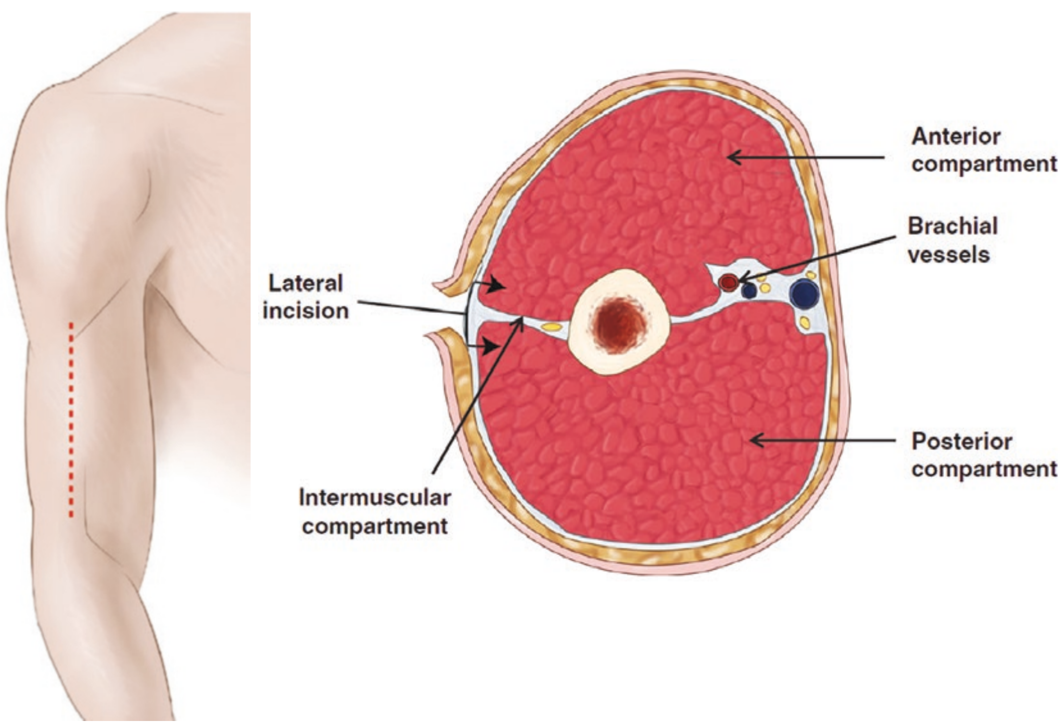

Fig. 110.2 The upper arm fasciotomy can be achieved through a single lateral incision (**left**). This incision is used to access the anterior and posterior compartments (**right**). (With permission, Atlas of Surgical Techniques in Trauma, eds Demetriades, Inaba, Velmahos, Cambridge University Press, 2015)

the skin incision, the subcutaneous tissue is dissected down to the muscular fascia, and the flexor muscle bellies are exposed and opened with scissors. Wide epimysiotomy (sectioning of the muscle sheath) is required over all muscle bellies of the volar forearm. An important component of the volar fasciotomy is the release of the carpal tunnel. The palmar fascia is incised to expose the transverse carpal ligament (flexor retinaculum), which has to be completely divided in order to fully decompress the carpal tunnel. The underlying median nerve, which is located directly deep in the divided flexor retinaculum, must be protected.

The dorsal compartment of the forearm is released by a longitudinal incision that begins 2 cm distal to the lateral epicondyle of the humerus and continues to the midwrist (Fig. 110.3). After exposure of the extensor muscle compartment, they are opened longitudinally.

The hand's oseofascial compartments can be released with carpal tunnel release (described above) and two dorsal incisions, which are made on the dorsum of the hand over the second and fourth metacarpal spaces (Fig. 110.3). On either side of each tendon, the compartments are opened with longitudinal slits in the fascia. To access and divide the fascia, the extensor tendon can be retracted.

110.3.2.3 Lower Extremity Fasciotomies

Fasciotomies of the buttocks are performed with the patient in the prone or lateral decubitus position. Decompression can either be done with a traditional question-mark incision or via a midaxial longitudinal incision.

The question mark incision starts lateral to the posterior superior iliac spine, courses laterally in a curvilinear fashion along the iliac crest toward the greater trochanter, then swings back medially along the inferior border of the buttock and extends over the midline of the posterior upper thigh (Fig. 110.4, top). The fascia of the gluteus maximus underlying the incision is encountered and released. To access the gluteus medius and minimus compartments, the gluteus maximus muscle needs to be split in a muscle-sparing fashion. The inferior part of the question mark incision is used to release the tensor fascia lata compartment.

Similar to the question mark incision, the midaxial longitudinal incision begins just lateral to the posterior superior iliac spine but then extends posterolaterally toward the lateral thigh (Fig. 110.4, bottom). At the greater trochanter, the incision proceeds inferiorly along the lateral aspect of the thigh. The access to the muscle compartments is identical to the description above for the question mark incision.

For thigh fasciotomies, the patient is placed in a supine position and prepped from the iliac crest to the foot. A lateral incision is performed to release the anterior and posterior thigh compartments. The medial compartment is rarely affected but could be decompressed by a medial incision. The incision starts just distal of the greater trochanter and continues in a linear way to a few cm proximal to the lateral femoral condyle (Fig. 110.5, top). The underlying fascia lata is encountered and divided with a longitudinal incision to decompress the anterior compartment. The posterior compartment is accessed after mobilization of a skin flap and incision of the fascia posterior to the intercompartmental septum. As an alternative, the posterior compartment can be accessed via the anterior compartment and the incision of the intercompartmental septum (Fig. 110.5, bottom).

For the lower leg fasciotomy, the compartments can be released using a two-incision approach. The lateral incision decompresses the anterior and lateral compartments, and the medial incision decompresses the superficial and deep posterior compartments.

The lateral incision is placed longitudinally, approximately two fingerbreadths anterior to the fibula. The incision starts two fingerbreadths below the fibular head and continues to two fingerbreadths above the lateral malleolus (Fig. 110.6, top). The skin and subcutaneous tissue are divided, and skin flaps are created to expose the underlying fascia covering the anterior and lateral compartments. For the anterior compartment decompression, a longitudinal incision is performed anterior to the septum, and

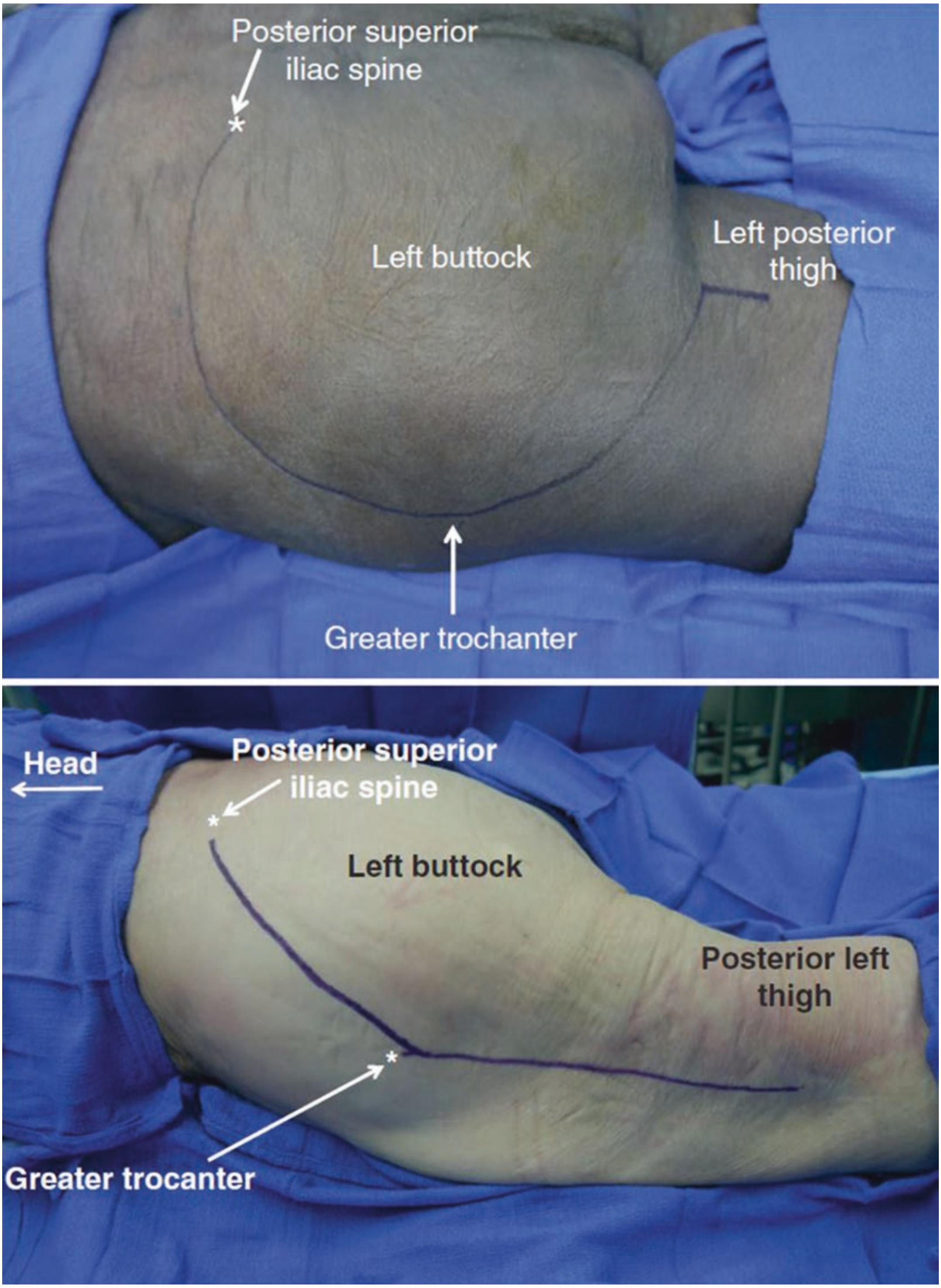

Fig. 110.4 The buttock compartments can be released using the question mark (top) or midaxial longitudinal incision (bottom). (With permission, Atlas of Surgical Techniques in Trauma, eds Demetriades, Inaba, Velmahos, Cambridge University Press, 2015)

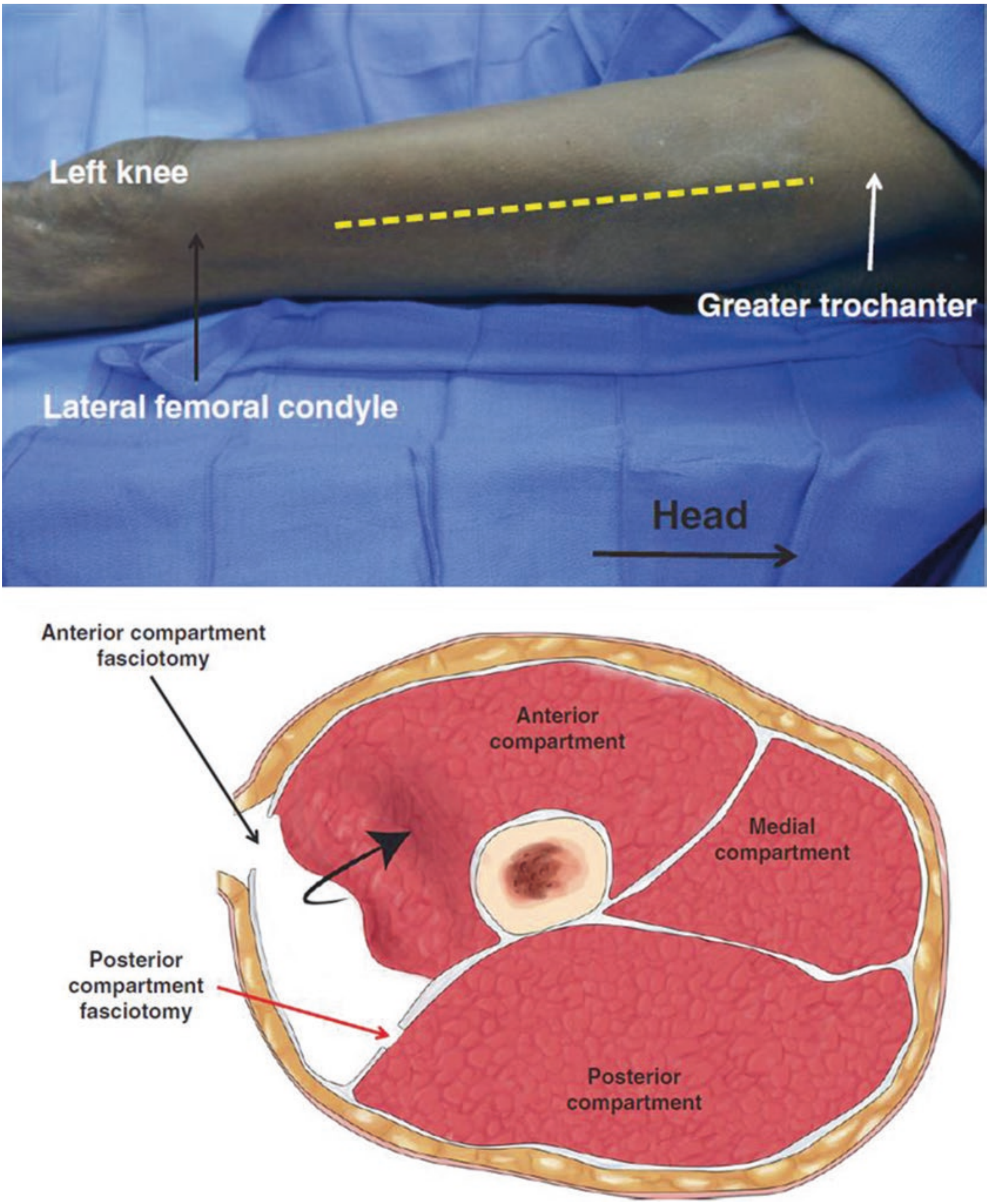

Fig. 110.5 The anterior and posterior compartments of the thigh are decompressed through a lateral incision (top). The anterior compartment is released directly, and the posterior compartment can be released directly through the development of a skin flap or by incising the intramuscular septum via the anterior compartment (bottom). (With permission, Atlas of Surgical Techniques in Trauma, eds Demetriades, Inaba, Velmahos, Cambridge University Press, 2015)

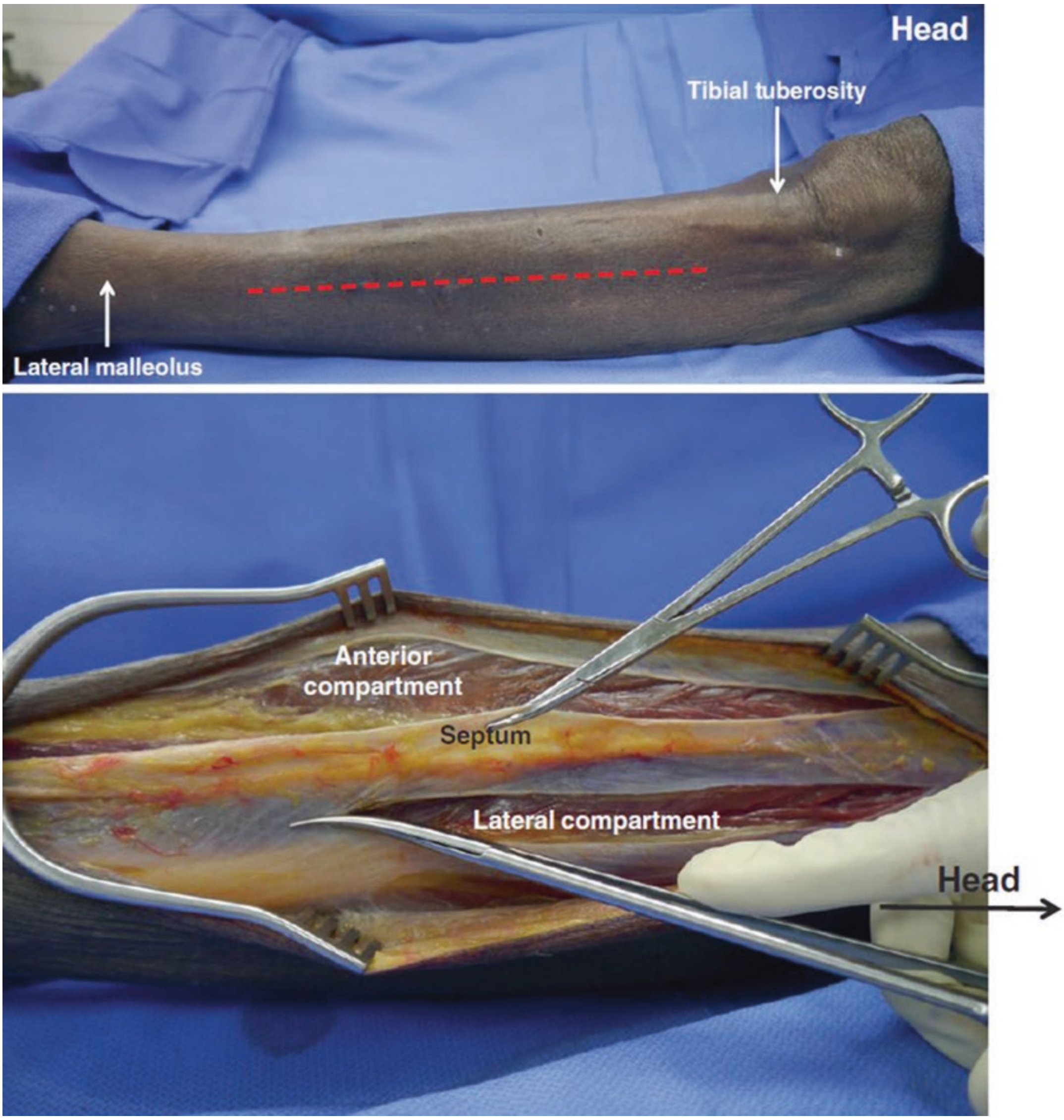

Fig. 110.6 The anterior and lateral compartments of the lower leg are decompressed through a lateral incision, which starts two fingerbreadths below the fibular head and ends two fingerbreadths above the lateral malleolus, in a line approximately two fingerbreadths anterior to the fibula (top). After exposure of the fascia, the septum, which separates the anterior and lateral compartments, is identified. Posterior to the septum, the lateral compartment is decompressed with long scissors (bottom). (With permission, Atlas of Surgical Techniques in Trauma, eds Demetriades, Inaba, Velmahos, Cambridge University Press, 2015)

the fascia is opened using long scissors, with the tips pointed toward the tibia tuberosity superiorly and the big toe inferiorly. For the lateral compartment decompression, a longitudinal incision is performed posterior to the septum, and the fascia is opened using long scissors, with the tips pointed toward the head of the fibula superiorly and the lateral malleolus inferiorly (Fig. 110.6, bottom).

The posterior lower leg compartments can be exposed through a medial incision, placed two fingerbreadths medial to the tibial edge. The incision starts two fingerbreadths below the medial aspect of the knee and extends two fingerbreadths

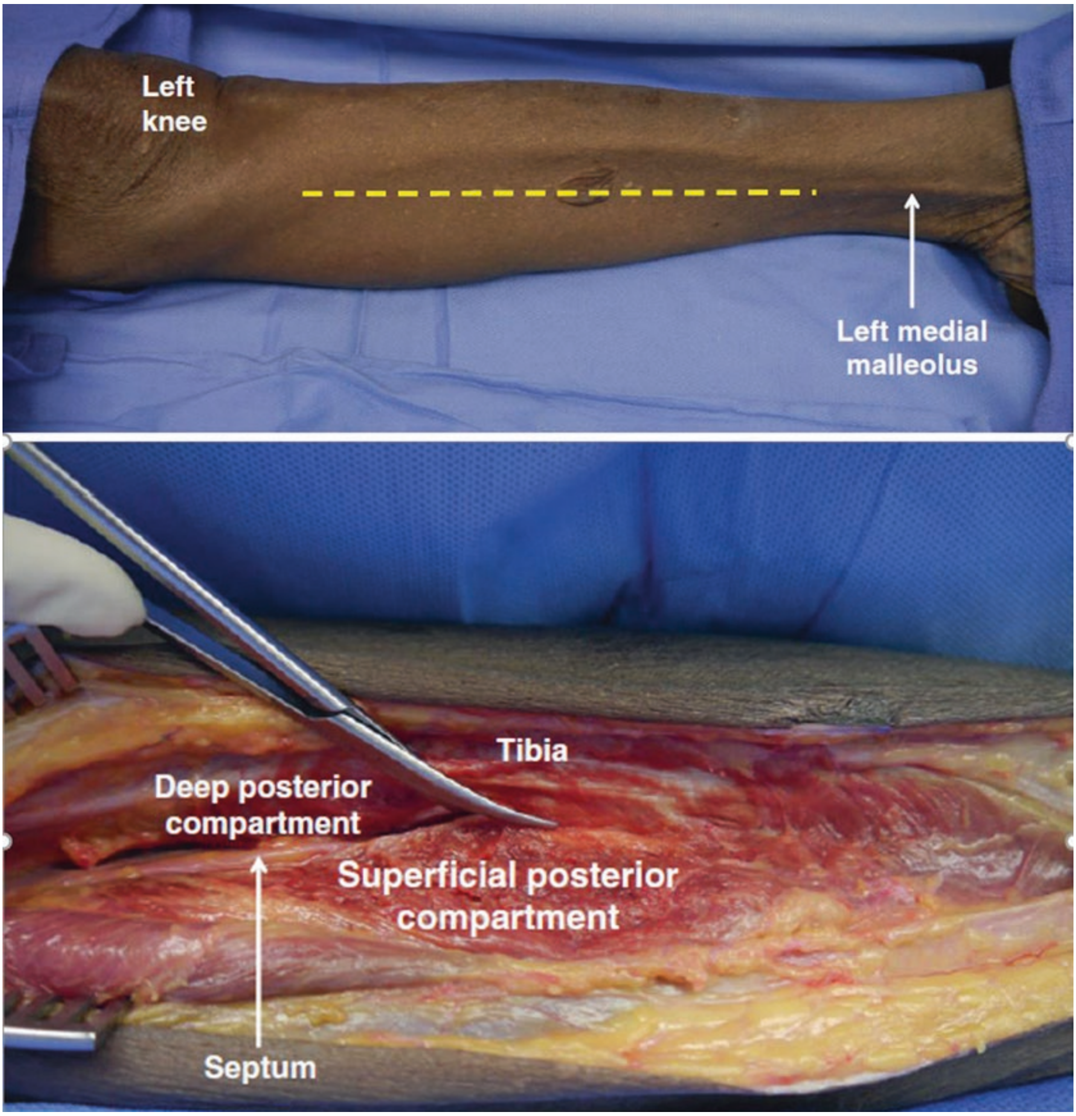

Fig. 110.7 The medial incision starts two fingerbreadths below the medial aspect of the knee and ends two fingerbreadths above the medial malleolus, in a line approximately two fingerbreadths medial to the tibia (top). The superficial compartment is released with a fascial incision, made about two fingerbreadths posterior to the tibia. The deep posterior compartment is best decompressed with a facial incision just behind the edge of the tibia (bottom). (With permission, Atlas of Surgical Techniques in Trauma, eds Demetriades, Inaba, Velmahos, Cambridge University Press, 2015)

above the medial malleolus (Fig. 110.7, top). The saphenous vein should be preserved. The superficial posterior compartment is encountered first and released by fascial incision. The deep posterior compartment is accessed by dividing the soleus from the posterior edge of the tibia along the shaft (Fig. 110.7, bottom). The identification of the posterior neurovascular bundle and the posterior surface of the tibia ensures the proper release of the deep compartment.

The foot compartments can be accessed and released by three incisions: a medial incision, which extends from a point below the medial malleolus to the metatarsophalangeal joint, and two dorsal incisions over the second and fourth metatarsal shafts. Ensure an adequate skin bridge between the two dorsal incisions to avoid necrosis. After the raising of the skin flaps, each of the interosseous compartments can be released. Avoid injuries to the neurovascular bundle when performing the medial incision.

110.3.3 Prognosis

Prognosis of the affected extremity depends on numerous factors, including associated soft tissue, neurovascular, and bony injuries, the duration and severity of ischemia, comorbidities, and most importantly time to fasciotomy. In general, early diagnosis with decompressive fasciotomy within 4 h of the onset of ischemia is associated with good functional outcomes. Delays of >4–6 h are associated with a high incidence of poor functional outcomes and limb loss.

Dos and Don'ts

Dos

- Have a high index of suspicion for extremity CS in high-risk patients.
- If in doubt about the clinical diagnosis, measure the pressures in all compartments of the involved anatomical area.
- Know the anatomy of the extremity compartments.
- During decompressive fasciotomy, perform a generous skin incision and a long fasciotomy. Explore all compartments!
- Excise nonviable muscle (not contracting on cautery stimulation).
- Perform liberal prophylactic fasciotomy in austere environments and whenever close monitoring is not possible or reliable.

Don'ts

- Do not cover the fingers or toes with dressings in high-risk patients.
- Do not escalate the dose of strong analgesics, before you rule out a CS in high-risk patients.
- Do not rely exclusively on clinical examination to rule out the diagnosis of CS. Clinical examination is often unreliable.
- Do not perform routine prophylactic fasciotomy if the patient can be closely monitored and reevaluated.

Take-Home Messages

- Delayed or missed extremity CS is common; therefore, a high index of suspicion, consideration of underlying risk factors, serial clinical examinations, pressure measurements, and serial CK levels are key factors to ensure early diagnosis and timely fasciotomy in extremity CS.
- Clinical examination alone is often not reliable in diagnosing early-onset extremity CS. Compartment pressures should be always measured if the clinical examination is inconclusive.
- Compartment pressures >30–40 mmHg or perfusion pressures <30 mmHg should prompt an emergency fasciotomy.
- Anatomical knowledge of the extremity compartments is essential for compartment pressure measurements, adequate decompressive fasciotomy, and prevention of iatrogenic injuries to the neurovascular bundle.

Multiple Choice Questions

1. Which of the following is true?
   A. Extremity muscle compartments can tolerate only 12 h of ischemia before muscle necrosis occurs.
   B. Physical exam is the primary method of diagnosing extremity CS in the obtunded patient as compartment pressures and CPK levels are unreliable.

   C. Mannitol is well tolerated in hypotensive patients as a treatment for extremity CS.
   D. Absolute compartment pressures greater than 30 mmHg or perfusion pressures less than 30 mmHg are concerning for extremity CS.

   Correct Answer: D

2. What anatomical area is most commonly affected by an extremity CS?
   A. Hand
   B. Forearm
   C. Thigh
   D. Lower leg

   Correct Answer: D

3. We suspect a lower leg CS. Which compartment is most likely to be affected?
   A. Anterior or lateral compartment
   B. Deep posterior compartment
   C. Superficial posterior compartment
   D. All compartments are equally affected

   Correct Answer: A

4. What is the earliest and most reliable clinical sign in a conscious and alert patient?
   A. Pallor
   B. Pain out of proportion
   C. Pulselessness extremity
   D. Poikilothermia

   Correct Answer: B

5. What is the next step in a clinically suspected extremity CS?
   A. Immediately proceed with fasciotomy
   B. Intracompartmental pressure measurement in all potentially affected muscle compartments
   C. Observation
   D. Elevation of the affected limb

   Correct Answer: B

6. Which of the following is false?
   A. A medial thigh incision is always required when performing a thigh fasciotomy, as the medial thigh compartment has a high incidence of CS.
   B. The anterior and lateral compartments of the lower leg are most commonly affected by CS.
   C. Entry into the deep posterior compartment is confirmed with visualization of the neurovascular bundle on the posterior aspect of the tibia.
   D. The serpentine volar incision of the forearm is insufficient to decompress all compartments of the forearm in the setting of CS.

   Correct Answer: A

7. What answer is correct about the fasciotomy of the thigh?
   A. Medial thigh incision is rarely needed because all muscle compartments (including the medial compartment) are accessible through a lateral incision.
   B. When performing a lateral incision to decompress a thigh CS, the saphenous vein is at risk.
   C. Medial incision has always to be performed when decompressing a CS of the thigh.
   D. Medial thigh incision is rarely needed because the medial muscle compartment is rarely affected.

   Correct Answer: D

8. Extremity compartment syndrome is more likely to develop in which group of trauma patients:
   A. Young male patients.
   B. Elderly female patients.
   C. Elderly male patients.
   D. Age does not matter.

   Correct Answer: A

9. The deep posterior compartment of the lower leg is the most commonly missed or incompletely released compartment. What is an easy way to identify this compartment after performing a medial incision?
   A. Identification of the posterior tibial neurovascular bundle just behind the medial edge of the tibia.

B. Identification of the saphenous vein.
C. Identification of the superficial peroneal nerve.
D. Identification of the anterior intermuscular septum of the lower leg.

Correct Answer: A

10. What is the most important factor defining the outcome of an extremity CS?
A. Adequate crystalloid-sparing resuscitation
B. Maintaining the mean arterial pressure
C. Early diagnosis with timely fasciotomy
D. Comorbidities of the patient

Correct Answer: C

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