Activity: Compartment Syndrome Booklet

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Target Audience: Orthopaedic surgery, ER, primary care

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Disclosures
No Planner/Author/Co-Author has any financial interest or other relationship with any manufacturer of commercial product or service to disclose.

Activity Objective: After reviewing the course materials, participants will be able to:
- Review cross section/anatomy of the extremities
- Describe the pathophysiology of compartment syndrome
- Diagnose patients presenting with compartment syndrome
- Discuss management of compartment syndrome and chronic compartment syndrome

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Compartment Syndrome Booklet
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**Definition**

Compartment syndrome is a condition in which increased pressure (from any source) within a closed space compromises the micro-circulation, and reduces perfusion to the tissue contained within the space.

**Sites**

Skeletal muscles are grouped in compartments that are enclosed by relatively non-compliant, fascial boundaries which define a limited space (and hence increase risk for compartment syndrome) in each of the following (Fig. 1).

![Figure 1: Body Sites for Compartment Syndrome.](image)

Compartment syndrome can affect any age group and can occur in multiple sites as seen in Figure 1. The most common site is the lower leg.
The increased pressure in the compartment may result from any of the etiologies shown in Figure 2.

**Fractures and Injuries**

Among the cases with acute compartment syndrome, tibial fracture was the most common.

Some of the common fractures associated with compartment syndrome are:

- Tibial fractures
- Calcaneal fractures
- Medial plateau fractures
- Severe and complex tibial fractures
- Medial knee fracture/dislocations
In the pediatric population, tibial tubercle fracture, both radius and ulna fracture, floating elbow injury, and supracondylar humerus fractures are the most common etiologies. Small children may not be able to verbalize their symptoms and increased analgesic requirement, agitation and anxiety are common symptoms. Presence of these findings (Analgesic, Agitation, and Anxiety) in a child should alert the clinician to the possibility of impending compartment syndrome.

**Soft Tissue Injury**

Soft tissue injuries are the second leading cause of compartment syndrome. It may result from major crushing trauma in crush syndrome, or minor blunt trauma over the anterior compartment of the leg or volar aspect of the forearm.

**Exercise**

Acute Exertional Compartment Syndrome: Exists when intra-compartmental pressure is elevated to a level and duration such that immediate decompression is necessary to prevent muscle necrosis. This usually occurs when an individual participates in a strenuous activity above his or her normal level of training.

**Vascular Injury/Hemorrhages**

Vascular injuries may cause blood to accumulate in the compartment, thereby raising the ICP (Intra Compartmental Pressure). Also, smaller blood leaks may over time evolve into a hematoma which may occlude blood flow thereby increasing the ICP as well.

**Decreased Compartment Size**

There are three causes of decreased compartment size:

1. Constrictive dressing and casts: A tight cast lowers compliance, and thus restricts the expansion of the tissue. It can elevate the pressure to ischemic levels in the compartment.

2. Thermal injuries and frostbite: Circumferential third degree burn can cause compartment syndrome due to inelastic scarring and/or edema formation.
3. Tight closure of fascial defects (muscle hernia) can cause ischemic complications. The physician should not close such defects.

**Other Causes**

Other causes of compartment syndrome include gunshot/stab wounds, arterial lines/IV, intraosseous IV (for infants), temporary ischemia, prolonged limb compression (drug overdose and general anesthesia), intramedullary nailing, pneumatic anti-shock garments (PASG), fluid infusion, osteotomy, snake bite, leukemic infiltration, acute hematogenous osteomyelitis, burns and electrical injuries.

**Risk Factors**

Risk factors for the development of acute compartment syndrome include:
- young age
- male
- tibial fracture
- high-energy forearm fracture
- high energy femoral fracture
- bleeding diathesis/anticoagulant
- chronic exertional compartment syndrome
Pathophysiology

A variety of conditions may initiate a sequence of events that produce compartment syndrome. The resting compartmental pressure is 0-10 mmHg. An increase of that pressure to 30 mmHg (or within 30 mmHg of diastolic blood pressure) will lead to impending compartment syndrome. If the elevated pressure is not relieved within 6-8 hours, irreversible damage to the contents of the compartments could occur.

Initiating Event

| Edema-Hemorrhage-Accumulation |
| Elevated Compartment Pressure |
| Venous Obstruction |
| Further Elevation of Compartment Pressure |
| Arteriolar Pressure Exceeded |
| Loss of Capillary Exchange |
| Muscle Ischemia/Infarction Nerve Damage |

↓

Irreversible Damage to Contents of the Compartment (muscles and nerves)
Muscle Changes

Within the first 3-4 hours of compartment syndrome, muscular changes are still reversible.

After 6 hours, there is clear muscle damage.

After 8 hours of established compartment syndrome, irreversible changes have occurred to the muscles.
Nerve Changes

1. Within the first 2 hours, there is a loss of nerve conduction.

2. After 4 hours, neuroproxia develops. The nerves survive, but no longer transmit impulses. Nerve changes are still reversible.

3. After 8 hours, there is total axonotomosis and secondary scar. If compartment syndrome progresses to this stage, irreversible changes occur to the nerves.
Anatomy

The most common anatomical sites for acute compartment syndrome are as follows: leg, forearm, foot, hand, and thigh.

1 is most common – 5 is least common

Fig. 3: The most common anatomical sites for developing compartment syndrome.
I. Anatomy of Leg

- The leg is the most common site in the body to develop compartment syndrome.
- There are four well defined compartments in the leg (Fig 4).
  - The anterior compartment is the most likely leg compartment to develop compartment syndrome.
  - The deep posterior compartment is the most commonly missed compartment in diagnosis of compartment syndrome of the lower leg.

![Figure 4: Compartments in leg.](image)

- The foot is innervated with four different nerves (Fig. 5 & Fig. 6).
  - Each of the four nerves are located in a different compartment, therefore, clinical examination of the foot alone can alert the clinician to the involved compartment.
  - The toe-web space is the most common site involved since it is innervated by the deep peroneal nerve, which is located in the anterior compartment.

![Figure 5: Innervation of the dorsal aspect of the foot.](image)
Figure 6: Innervation of the plantar aspect of the foot. (posterior tibial nerve which is located in the deep posterior compartment).

Compartments of the Leg

1. **Anterior compartment** (Fig.4) (Sensation to first web space)
   a. **Muscles**: Dorsiflexors of the foot
   b. **Nerves**: Deep peroneal nerve

2. **Lateral Compartment** (Fig.4) (Sensation to dorsum of the foot)
   a. **Muscles**: Peroneal muscles
   b. **Nerve**: Superficial peroneal nerve

3. **Superficial Posterior Compartment** (Fig.4) (sensation to lateral aspect of the foot)
   a. **Muscles**: Gastrocnemius, Soleus
   b. **Nerves**: Sural nerve

4. **Deep Posterior Compartment** (Fig.4) (Sensation to the plantar aspect of the foot via multiple branches)
   a. **Muscles**: Toe flexors, Tibialis posterior
b. **Nerves:** Posterior tibial Nerve

## II. Anatomy of Forearm

The forearm is comprised of four compartments: **Superficial Volar Compartment,** **Deep Volar Compartment,** **Henry’s mobile Wad** and the **Dorsal Compartment** (Fig 7).

1. **Superficial Volar Compartment**
   a. **Muscles:** PT, FCR, PL, FCU, FDS
   b. **Nerves:** Median and Ulnar nerve

2. **Deep Volar Compartment**
   a. **Muscles:** FDL, FPL, PQ
   b. **Nerves:** Anterior interosseous Nerve

3. **Henry’s mobile wad**
   a. **Muscles:** BR, ECRL, ECRB
   b. **Nerve:** Radial nerve

4. **Dorsal Compartment**
   a. **Muscles:** Anconeus, EDC, EDQ, ECU, Supinator, APL, EPB, EPL, EIP
   b. **Nerves:** Radial and Posterior Interosseous nerve

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*Figure 7: Transverse section through mid-forearm with fascial compartments shown.*
III. Anatomy of Hand

Figure 8: Transverse section through the hand with the ten fascial compartments shown.

Compartments of the Hand

There are ten well defined compartments in the hand (Fig 8):

1. **Thenar Compartment**  
   a. **Muscles**: ABP, OP, FPB, Adductor Pollicis

2. **Hypothenar Compartment**  
   a. **Muscles**: ADM, FDM and ODM

3. **Adductor Pollicis Compartment**  
   a. **Muscles**: Adductor Pollicis muscles

4. **Volar Interossei Compartment**  
   a. **Muscles**: Volar Interossei  
   b. **Nerves**: Radial and Posterior Interosseous nerve

5. **Dorsal Interossei Compartment**  
   a. **Muscles**: Dorsal Interossei
IV. Anatomy of Foot

Figure 9: Transverse section through the foot showing the nine compartments.

**Compartments of the Foot**

There are nine well defined compartments in the foot (Fig 9):

1. **Interosseous Compartment (4 compartments)**
   a. **Four Interossei Compartments**: contain the 4 interossei muscles

2. **Central Compartment (2 compartments)**
   a. **Deep Central Compartment**: contains the Quadratus Planus Muscle
   b. **Superficial Central Compartment**: FDL and FDB muscles, communicates with the DPC of the leg.

3. **Adductor Hallucis Compartment (1 compartment)**
   a. **Muscles**: Adductor Hallucis muscles

4. **Medial Compartment (1 compartment)**
   a. **Muscles**: Volar Interossei

5. **Lateral Compartment (1 compartment)**
   a. **Muscles**: Flexor Digiti Minimi Brevis and the adductor digiti minimi muscles
V. Anatomy of Thigh

Figure 10: Transverse section through the mid-thigh with fascial compartments shown.

Compartments of the Thigh

There are three compartments in the thigh: The anterior, posterior and the medial compartments (Fig 10).

1. **Anterior compartment**
   a. **Muscles**: Quadriceps Femoris and the Sartorius Muscles
   b. **Nerves**: Femoral nerve and Saphenous nerve → these supply the medial leg and ankle.

2. **Posterior Compartment**
   a. **Muscles**: Semimembranosus, Semitendinous and Biceps Femoris
   b. **Nerve**: Sciatic nerve

3. **Medial Compartment**
   a. **Muscles**: Adductor Longus and Adductor Brevis
   b. **Nerves**: Obturator nerve
Diagnosis of Compartment Syndrome

The diagnosis of Compartment Syndrome is primarily established through a clinical exam. Pressure measurement can support the diagnosis, especially when the clinical exam is equivocal or diagnosis needs to be confirmed. Compartment syndrome can happen at any age, even after minor trauma. Therefore, the physician must keep a high index of suspicion.

I. Clinical Exam (the most sensitive screening tool)

Initial Findings: --- Impending Stage

A. Pain: The earliest and the most reliable indicator is pain that is more than expected from the injury or surgery.
B. Pain with passive stretch: Stretch of the muscles in the involved compartment will elicit pain.
C. Swelling: A swollen and tense compartment is a direct manifestation of increased intra-compartmental pressure.

Initial findings should be used to diagnose compartment syndrome. DO NOT wait for late findings to establish a diagnosis.

Late Findings: --- Established Stage

A. Paresthesia: Paresthesia and/or dysesthesia present in the distribution of nerves affected in the involved compartment.
B. Paresis: Loss of motor function innervated by affected nerve is usually a late diagnosis.
C. Pulselessness: Only rarely does the compartment pressure become elevated sufficiently to occlude a major artery (DO NOT wait for a decreased pulse to establish the diagnosis and perform the fasciotomy).
II. Pressure Monitoring

Figure 11: Multiple devices could be used to obtain a direct pressure measurement of the desired compartment.

A. Most reliable method to confirm and support the diagnosis of compartment syndrome, although it must be reiterated that compartment syndrome is a clinical diagnosis.

B. Normal resting muscle pressure is 0-10 mm Hg.

C. Threshold for fasciotomy is recommended at an absolute pressure of 30 mm Hg, or within 30 mm Hg of the diastolic blood pressure, called the pressure gradient and denoted by $\Delta P$. $\Delta P$ is defined by the equation:

$$\Delta P = \text{Diastolic Blood Pressure} - \text{Intracompartmental pressure}$$

D. Fasciotomy is indicated within 6 hours as soon as the diagnosis is made. After 6 hours, damage to the nerve and muscle is irreversible and may lead to muscle necrosis and nerve death.
III. Methods of Measurement

A. **Stic Catheter:** A quick and simple commercially available digital pressure measurement device

B. **Arterial line set:** I.C.U. monitor can be connected to an arterial line, and the system is then calibrated to the mean arterial blood pressure. The needle is inserted into the compartment and direct reading is obtained.

*** Do not inject deeply to avoid raising compartment pressure
**Differential Diagnosis of Compartment Syndrome**

1. If the patient has no pain with passive stretch, but their pulses are intact, they likely have nerve injury (Table 2).
2. If high intra-compartment pressure is detected (>30 mmHg), the patient likely has compartment syndrome (Table 2).
3. If the patient lacks a pulse, but has pain with passive stretch and normal intra-compartmental pressure, they likely have arterial injury (Table 2).
4. Paresthesia/Anesthesia and Paresis/Paralysis are not specific findings and not useful in establishing the diagnosis (Table 1).

**Table 1: Non-specific clinical findings**

<table>
<thead>
<tr>
<th></th>
<th>Compartment Syndrome</th>
<th>Arterial Occlusion</th>
<th>Neuroproxia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Paresthesia or Anesthesia</strong></td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>Paresis or Paralysis</strong></td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

**Table 2: Differential Diagnosis with clinical findings**

<table>
<thead>
<tr>
<th></th>
<th>Compartment Syndrome (CS)</th>
<th>Arterial Occlusion</th>
<th>Neuroproxia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pain with Passive Stretch (PPS)</strong></td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><strong>Intact Pulse</strong></td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><strong>Increased Intra-Compartmental Pressure (ICP)</strong></td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Comments**
- Pain with passive stretch along with increased ICP is suggestive of CS. Loss of pulse is a late finding and pulse may be intact in early stages.
- Loss of pulse in the extremity and normal ICP along with PPS is suggestive of Arterial occlusion.
- Normal ICP and intact pulse along with absence of PPS is suggestive of Nerve injury.

**Treatment**
- Fasciotomy
- Repair and Vascular Consult
- Exploration and/or Observation
Treatment

I. Release of Constrictive Dressing

A. Cast splitting and relief of pressure should be performed when pain is severe or neurological deficit is observed.

B. Removal of the cast and all circular dressing is mandatory and should be done urgently if symptoms persist.

C. Compartment Pressure falls by 30% when cast is split on one side and when cast is spread after splitting the pressure falls further.

D. Substantial total pressure reduction after removing the cast.

***DO NOT elevate a limb with compartment syndrome***

E. Once the diagnosis of compartment syndrome is established by clinical exam (and pressure monitoring if necessary), fasciotomy is indicated emergently. Decompression of all compartments with elevated pressure is mandatory (through multiple generous incisions). For example, in the lower leg, fasciotomy is done to decompress all four compartments.

F. Bedside fasciotomy is an acceptable form of treatment if the patient cannot undergo surgery in the operating room for whatever reason. Bedside Fasciotomy may be done on the floor, in the ER or in the ICU.
II. Surgical Decompression (Fasciotomy)

A. Leg (All four compartments can be released through either one or two incisions, Fig.12)

Figure 12: Cross section of four compartment fasciotomies of the leg (classical two incision technique).

1. Lateral Incision: For release of the anterior and lateral compartments halfway between the tibia and fibula. This incision will open both anterior and lateral compartments (beware of the superficial peroneal nerve).

2. Medial Incision: For release of the superficial and deep posterior compartments – 2 cm posterior to the medial border of the tibia. This incision will open both superficial and deep compartments (beware of the saphenous vein and nerve).
B. Forearm: The volar compartment, superficial and deep, must be released through an ample volar incision when involved. The carpal tunnel may need to be released as well. The dorsal compartment can be released through an incision over the dorsum of the forearm (Fig. 15 & 16).

1. Volar Incision: For release of the superficial and deep volar compartments as well as the mobile wad (Fig. 13 & 14). The surgeon must be cautious of the superficial radial nerve.

Figure 13: Volar approach to flexor compartments of the forearm.

Figure 14: Transverse section of forearm showing volar fasciotomy.
2. **Dorsal Incision**: For release of dorsal compartment (Fig. 15 & 16)

**Figure 15**: Dorsal approach to the extensor compartment of the forearm.

**Figure 16**: Transverse section of forearm showing dorsal fasciotomy.
Chronic Exertional Compartment Syndrome

Definition

Chronic exertional compartment syndrome (CECS) is an exercise-induced neuromuscular condition that occurs when a compartment cannot accommodate the increase in muscle volume during exercise.

Anatomy

CECS affects the lower leg bilaterally in 80-95% of patients, but it has also been reported to affect compartments of the forearm, hand, thigh, and foot.

In the lower leg, CECS will affect:

- Anterior leg compartment (40-60%)
- Deep posterior compartment (32-60%)
- Lateral compartment (12-35%)
- Superficial posterior compartment (rarely)

CECS will very rarely affect the compartments of the forearm and the hand.

Fascial herniations may be evident in up to 40-60% of patients.

Pathophysiology

1. Increased blood flow during strenuous exercise can cause up to a 20% increase in muscle volume and weight.

2. In CECS patients, the osteofascial compartment cannot accommodate the expanding tissue volume, which raises the intra-compartmental pressure.

3. While the elevated pressure may lead to ischemia and pain, it is not enough to cause irreversible damage to the tissues.

4. However, the high pressure does cause pain, tenderness, swelling, paresthesia, and weakness, usually necessitating the cessation of activity.

5. The symptoms may be due to relative ischemia, stimulation of the fascial or periosteal sensory nerves by increased compartmental pressure, or the release of kinins.
(polypeptides that relax smooth muscle cells and widen blood vessels) in response to reduce blood flow.

**Differential Diagnosis**

The following conditions can mimic CECS:

- Medial Tibial Stress Syndrome (Shin Splints)
- Stress Fracture
- Deep Vein Thrombosis (DVT)
- Nerve Entrapment
- Vascular Disorders
- Radiculopathy
- Fascial Defects

**Clinical Presentation**

1. Chronic exertional compartment syndrome presents bilaterally in 80-95% of patients. The anterior compartment of the lower leg is most frequently affected.

2. Physical examination is often normal before exercise, but symptoms typically develop within the first twenty minutes of activity.

3. Symptoms usually necessitate the cessation of activity and are relieved by rest. They return when exercise is started again.

4. Patient experiences recurrent pain described as a feeling pressure of cramping over the anterior or lateral compartment initiated by exercise.

5. The onset of pain is reproducible and predictable for a specific speed and/or distance and intensity.

6. The pain starts as a dull ache diffuse over the involved compartment and progresses into cramping, burning, or tightness.

7. Continued exercise may lead to paresthesia, numbness, or weakness of the extremity secondary to nerve compression in the involved compartment. If left untreated, symptoms will worsen and in extreme cases, and will become constant after sometime.
8. Post-exercise physical examination often reveals a tense compartment that is painful upon deep palpation. Hernia may be present in up to 40-60% of cases.

**Diagnosis**

1. Diagnosis is primarily clinical; the clinician must take a thorough history and perform a detailed physical examination.

2. Typically, the physical examination will be normal and there will be no pain present at rest.

3. However, pain can be reproduced on exertion and is relieved on rest.

4. Pressure measurement can then be used to confirm the suspected diagnosis since a number of conditions may mimic CECS.

5. Diagnosis is made by intra-compartmental pressure measurement.

6. One or more of the following pressure measurements is acceptable:

   - Pre-exercise pressure measurement >15 mmHg
   - Post-exercise pressure measurement at one minute >30 mmHg
   - Post-exercise pressure measurement at five minutes >20 mmHg

**Treatment**

1. Conservative treatments include cessation of causative activity, rest, ice, physical therapy, and deep massage; however, they are often unsuccessful.

2. Fasciotomy is recommended to normalize both resting and post-exercise pressure and prevent irreversible ischemic changes to muscle and nerve within the affected compartments.
Clinical Pearls:

1. Ten percent of patients with low velocity gunshot wound to the proximal forearm will develop compartment syndrome. This group of patients requires admission to the hospital for observation for at least 24 hours.

2. Compartment syndrome can develop postoperatively following intra-medullary nailing for fixation of long bone fractures.

3. Compartment syndrome can occur in the presence of open fractures.

4. A child or patient with head and extremity injuries needs constant monitoring to diagnose compartment syndrome.

5. In children, agitation and pain that continues after a fracture reduction should raise suspicion of compartment syndrome.

7. Epidural anesthesia may mask the symptoms of compartment syndrome in the post-operative period.

8. Arterial line can cause compartment syndrome in the hand.

9. The pneumatic anti-shock garment (PASG) may be associated with compartment syndrome, particularly if applied over an injured leg and left inflated for prolonged period of time. Prolonged application of the PASG on an uninjured extremity may also produce compartment syndrome.

10. Crush injury to an extremity can lead to compartment syndrome.

11. If compartment syndrome is not treated, permanent paralysis and/or necrosis may result. The end stage is called Volkmann’s ischemic contracture.

12. Missed deep posterior compartment syndrome in the leg can cause claw toes.

13. When performing a fasciotomy for compartment syndrome of the volar compartment of the forearm, carpal tunnel may have to be released (but that’s not always the case).

14. Prophylactic fasciotomy should be considered in patients with vascular injury, for example as in vascular repair following knee injury.
15. Crush syndrome occurs as a result of prolonged continuous pressure on muscle tissue, with resultant myoglobinuria and subsequent risk of renal failure.

16. In the case of compartment syndrome of the anterior thigh, simple release of the tensor fascia lata may be adequate to decompress the anterior compartment.
Reference Sheet


Compartment Syndrome Post Test

1. When the measured pressure in a compartment is 40 mmHg and the diastolic BP is 65 mmHg, what is the appropriate action?
   A. Observation
   B. Elevation
   C. Application of ice
   D. Decompression

2. The normal resting intracompartmental pressure is:
   A. 0-10 mmHg
   B. 20 mmHg
   C. 40 mmHg
   D. 70 mmHg

3. Arterial pulse in compartment syndrome is:
   A. Always Absent
   B. Always Present
   C. Could be Normal
   D. None of the Above.

4. Which nerve gets involved with increased pressure in the anterior compartment of the leg?
   A. Saphenous nerve
   B. Superficial peroneal nerve

5. The most commonly affected compartment in compartment syndrome of the leg is:
   A. Deep posterior compartment
   B. Lateral compartment
   C. Anterior compartment
   D. Superficial posterior compartment

6. The most commonly missed compartment of the leg is:
   A. Deep posterior compartment
   B. Lateral compartment
   C. Anterior compartment
   D. Superficial compartment

7. While performing decompression of the lateral compartment of the leg, care must be taken to avoid injury to?
   A. Sural nerve
   B. Superficial peroneal nerve
   C. Saphenous nerve
   D. Deep peroneal nerve
8. In case of compartment syndrome affecting the leg, how many compartments are released?

A. One compartment
B. Two compartments
C. Three compartments
D. Four compartments

9. How many compartments are there in the volar aspect of the forearm?

A. One compartment
B. Two compartments
C. Three compartments
D. Four compartments

10. The thigh has how many compartments?

A. One
B. Two
C. Three
D. Four

11. The sciatic nerve is located in which compartment of the thigh?

A. Anterior
B. Posterior
C. Medial
D. Lateral

12. In the case of compartment syndrome of the anterior compartment of the thigh, which nerve(s) is/are affected?

A. Saphenous and/or Femoral
B. Sciatic
C. Obturator

13. The medial compartment of the thigh contains which nerve?

A. Sciatic
B. Obturator
C. Saphenous
D. Femoral

14. The presence of compartment syndrome of the anterior thigh will produce paresthesia in the:

A. Dorsum of the foot
B. Plantar aspect of the foot
C. Lateral ankle
D. Medial leg and ankle

15. Low velocity gunshot wounds in the forearm are associated with compartment syndrome in:

A. 2% of patients
B. 10% of patients
C. 15% of patients
D. 30% of patients
16. The most common site of chronic exertional compartment syndrome is:
   A. Leg
   B. Thigh
   C. Forearm

17. A patient with a fractured tibia treated by a long cast complaining of severe pain at night. The appropriate action is:
   A. Reassure the patient
   B. Elevate the leg
   C. Pain medication
   D. Split the cast and examine the leg

18. How many compartments are in the Hand?
   A. 5
   B. 7
   C. 9
   D. 10

19. Compartment syndrome could be caused by:
   A. Intramedullary nailing of long bones
   B. The use of anti-shock garment trousers
   C. Tight dressings
   D. All of the above

20. The most common fracture associated with compartment syndrome is:
   A. Femoral Diaphyseal Fracture
   B. Distal Radius Fracture
   C. Tibial Diaphyseal Fracture
   D. Tibial Plateau Fracture

21. Prophylactic fasciotomy is often needed in case of:
   A. Tibia fracture
   B. Femur fracture
   C. Knee dislocation with vascular repair
   D. Hip fracture

22. The Perfusion Pressure Gradient (\(\Delta P\)) is a relative pressure measurement derived using which equation?
   A. Diastolic Blood Pressure minus Intra-Compartmental Pressure
   B. Systolic Blood Pressure minus Intra-Compartmental Pressure
   C. Mean Arterial Pressure minus Intra-Compartmental Pressure
23. Muscle damage due to ischemia is still reversible within:
   A. 3-4 hours
   B. 5-6 hours
   C. 6-8 hours
   D. 10-12 hours

24. Nerve changes are still reversible within:
   A. 1-2 hours
   B. 3-4 hours
   C. 7-8 hours

25. The resting intra-compartmental pressure in a patient with chronic exertional compartment syndrome is usually at or above _____?
   A. 5 mmHg
   B. 10 mmHg
   C. 15 mmHg
   D. 20 mmHg

26. Which of the following is indicative of exertional compartment syndrome?
   A. Pressure before exercise is 10 mmHg
   B. Pressure during exercise reaches 60 mmHg
   C. Pressure remains over 20 mmHg for 1 minute after cessation of causative activity, then begins to decline
   D. Pressure remains over 20 mmHg for more than 5 minutes after the end of exercise

27. A young patient with pain after surgery for fracture fixation of the radius and ulna has a swollen forearm. Passive motion of the fingers causes pain with increased analgesic requirements. What is the appropriate next step?
   A. Elevate the forearm
   B. Increased pain medications
   C. Add a splint for more fracture support
   D. Measure the forearm compartment pressure

28. What are the earliest signs and symptoms of a developing compartment syndrome in the forearm?
   A. Absent pulses
   B. Inability to move the fingers
   C. Decreased sensation in the fingers
   D. Pain out of proportion to the injury or surgery
29. A patient with a right tibial fracture has a blood pressure of 120/80 mmHg. Which of the following is most reliable for the diagnosis of compartment syndrome?

A. An intra-compartmental pressure of 25 mmHg
B. Swelling of the limb
C. Weak capillary refill
D. A delta pressure of 20 mmHg
E. Diffuse edema of the lower limb

30. How many compartments are in the Foot?

A. 5
B. 7
C. 9
D. 10
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