PATHOPHYSIOLOGY AND RISKS OF PNEUMATIC TOURNIQUET USE

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STUDY GUIDE

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2170 South Parker Road, Suite 400,
Denver, CO 80231-5711
(800) 755-2676
www.aorn.org

Video produced by Cine-Med, Inc.
127 Main Street North, Woodbury, CT 06798
Tel (203) 263-0006 Fax (203) 263-4839
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# Pathophysiology and Risks of Pneumatic Tourniquet Use

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PURPOSE/GOAL/OBJECTIVES
After viewing the video and completing the study guide, the learner will be able to:

• Describe the body’s physiologic responses to inflation and deflation of a pneumatic tourniquet.
• Relate these physiologic responses to local and systemic complications that have been reported for patients who have undergone pneumatic tourniquet-assisted procedures.
• List patient-specific and practice-specific risk factors for complications related to pneumatic tourniquet use.
INTRODUCTION

Pneumatic tourniquets are used during surgery to occlude blood flow to an extremity and create a near bloodless surgical field and to provide intravenous regional anesthesia. Reports of patients suffering serious complications after pneumatic tourniquet-assisted procedures are rare, but local and systemic injuries can occur and can be severe. For this reason, experts continue to debate the use of pneumatic tourniquets during surgical procedures.

Exsanguination, pneumatic tourniquet inflation, and subsequent deflation cause local and systemic physiologic responses that perioperative nurses must understand to have a better grasp of the patient’s risk for pneumatic tourniquet-related complications. By understanding patient- and practice-specific risk factors for pneumatic tourniquet-related complications, perioperative nurses also can communicate and collaborate effectively with anesthesia professionals and surgeons; assess and monitor patients before, during and after surgery; and decrease the likelihood of adverse outcomes from pneumatic tourniquet use.

EFFECTS OF PNEUMATIC TOURNIQUET INFLATION

Hemodynamic effects
When a pneumatic tourniquet is used during surgery, exsanguination of the extremity and cuff inflation cause blood to rapidly shift from the extremity into the central blood circulation. This causes an increase in circulating blood volume and systemic vascular resistance, which in turn causes a transient increase in systolic blood pressure and central venous pressure.

In most cases, the hemodynamic effects of pneumatic tourniquet inflation are not harmful to patients. However, patients with cardiac ventricular noncompliance, diastolic dysfunction, and other cardiac abnormalities may not tolerate rapid hemodynamic changes, particularly when substantial hypervolemia occurs, such as during simultaneous bilateral lower limb exsanguination.

Hematologic effects
Surgery may induce hypercoagulability, whether or not a pneumatic tourniquet is used. However, pneumatic tourniquet use can directly affect blood coagulability and fibrinolysis. Pneumatic tourniquet inflation and perioperative pain initially may cause systemic hypercoagulability, while deflation is associated with a transient 30-minute increase in peripheral blood thrombolysis. The resulting decreased coagulability has been associated with increases in post-surgical bleeding.

In a small randomized study, half of a group of 24 patients undergoing total knee arthroplasty were assigned to have pneumatic tourniquets used during surgery while the other half served as controls. Laboratory assays identified increased platelet, leukocyte, and endothelial activity and interaction as well as increased whole blood coagulation in the pneumatic tourniquet group compared to the control group.

Temperature effects
Typically, there is an increase in core body temperature while the pneumatic tourniquet is inflated. This is probably because there is less movement of blood from central to peripheral compartments and because there is decreased heat loss from the skin of the occluded extremity or extremities.

Children are especially prone to increases in core body temperature during pneumatic tourniquet assisted surgery. The perioperative team should ensure that patients, especially children, do not become overheated while the pneumatic tourniquet is inflated.

Effects on peripheral nerves
Nerve conduction failure can occur beneath the pneumatic tourniquet as soon as 10-20 minutes after cuff inflation. Anesthesia at the surgical site is augmented both by conduction nerve failure and by cooling of the tissue of the extremity, which results from isolation of the occluded extremity from the central circulation. Electrophysiologic testing and neurologic examination can help distinguish postoperative pneumatic tourniquet-induced peripheral nerve abnormalities from more proximal injuries secondary to an epidural or spinal anesthesia.

Nerve injury secondary to pneumatic tourniquet use ranges from mild, transient functional impairment to permanent, irreversible nerve damage. Nerve injury is most likely to occur beneath and near the edges of the inflated pneumatic cuff and is thought to primarily result from direct compressive
forces, rather than ischemia or muscle damage. \(^9^{\text{-}}^{10}\) Nerve injuries are more common in upper limbs than lower limbs, and the radial nerve is most commonly affected. \(^4\) Compression of large myelinated nerves causes positional displacement of nodes of Ranvier from the normal position beneath the Schwann cell junction; stretching and invagination of myelin sheaths; microvascular damage; edema; and ischemia resulting from nutritional depletion in the tissues. \(^4^{\text{-}}^{10}\)

**Tourniquet pain**
When inflation pressure exceeds systolic blood pressure by 100 mm Hg or more for more than several minutes, awake patients usually experience pneumatic tourniquet pain. \(^3\) In patients under general anesthesia, pneumatic tourniquet pain usually manifests as increases in heart rate, and systolic and diastolic blood pressure that begin approximately 30 minutes after cuff inflation and continue until the pneumatic tourniquet is deflated.

Pneumatic tourniquet pain appears to have multiple complex causes and is thought to result from the transmission of pain signals along slow-conducting, unmyelinated C-fibers. \(^10\) Mechanical compression prevents fast-conducting myelinated A-δ-fibers from blocking these pain signals as they normally would. \(^11\) Pneumatic tourniquet pain increases with duration of tourniquet inflation and can become severe enough that additional supplemental analgesia or general anesthesia is required, even if the patient has a regional block that is adequate for surgical anesthesia. \(^3\)

Several factors influence the probability of pneumatic tourniquet pain and its associated signs and symptoms. These include anesthetic technique (ie, regional versus general anesthesia), choice and dose of local anesthetic, the area covered by the anesthetic nerve block, and whether intravenous or local anesthetic adjuvants are used. \(^3\)

Longer periods of pneumatic tourniquet inflation trigger additional stimulation and progressive activation of the sympathetic nervous system. \(^3\) Beginning approximately one hour after cuff inflation, stimuli from pneumatic tourniquet compression can gradually increase mean arterial blood pressure. Ongoing sympathetic nervous system activation manifests as hypertension, tachycardia, and diaphoresis (sweating). Deflation of the pneumatic tourniquet typically relieves tourniquet pain. \(^3\)

**Compartment syndrome**
Compartment syndrome, a relatively rare complication of pneumatic tourniquet use, occurs when an extremity swells because of a combination of external and internal pressures on a restricted or confined space between two fascia layers of a muscle group. \(^12\) When caused by a pneumatic tourniquet, compartment syndrome specifically results from prolonged ischemia leading to tissue acidosis, increased capillary permeability, and prolonged clotting times. Symptoms of this relatively rare condition begin as increasingly severe pain that does not respond to narcotics, and may progress to include muscle weakness, paresthesia, decreased or absent pulses, tense skin over the limb, and irreversible paralysis. \(^12\)

Patient risk factors for pneumatic tourniquet-related compartment syndrome include a prior history of compartment syndrome; McArdle’s disease (ie, a deficiency in muscle phosphorylase); and the application of a cast or a compressive bandage before pneumatic tourniquet release, which physically inhibits post-tourniquet swelling and causes build-up of pressure. \(^12\)

**Muscle injury**
Symptoms and signs of muscle injury secondary to pneumatic tourniquet use include pain or tenderness of the limb and decreased functional strength, contractile speed, and fatigability of the muscles. \(^13\) Muscle injury results from a combination of cuff pressure and duration of cuff inflation. Muscle injuries tend to be most severe just beneath the cuff, because of a combination of mechanical forces and ischemia at this location. \(^4^{\text{-}}^{12}\) Microvascular congestion may persist after cuff deflation, leading to persistent muscle injury. \(^4\)

Rhabdomyolysis, or release of cellular contents from skeletal muscle damage, may cause fever and tachycardia and the patient may experience possible pain or tenderness, swelling of the extremity, and hemorrhage at the surgical site. Dark urine and oliguria also may occur. Rhabdomyolysis requires prompt identification and treatment to prevent long-term sequelae. \(^14\)

**Skin injury**
Localized compression-related tissue damage from pneumatic cuff use can include blisters, cutaneous abrasions, and pressure necrosis. \(^4^{\text{-}}^{6}\) These complications are uncommon, but may occur when an overinflated pneumatic tourniquet exerts excessive pressure on underlying tissue. \(^2\) Unpadded pneumatic tourniquet cuffs or tourniquet cuffs that migrate away from underlying padding during surgery also can cause traumatic shearing injuries and friction burns. \(^6\) Chemical burns can result from inadvertently allowing alcohol-based skin preparations to seep into the padding beneath the pneumatic tourniquet. \(^6\)
EFFECTS OF PNEUMATIC Tourniquet Deflation

Limb reperfusion on tourniquet deflation leads to reduced central blood volume and decreased systemic vascular resistance, which cause decreases in heart rate and central arterial and venous pressure. Hypotension may persist for up to one hour after cuff deflation and results from the sudden decrease in peripheral vascular resistance, as well as bleeding at the surgical site, reactive vasodilation, and microvascular permeability.²,¹³

The volume of ischemic tissue (eg, bilateral versus unilateral; lower limb versus forearm) and the duration of tourniquet inflation time influence the severity of potential effects when the tourniquet is deflated.² These effects include decreased core body temperature; decreased heart rate; transient hypotension; mixed acidosis with impaired pulmonary gas exchange; reperfusion injury; and deep vein thrombosis with potential pulmonary embolism.

Temperature effects

When the pneumatic tourniquet is deflated, cooler blood trapped in the extremity re-enters the systemic circulation, resulting in decreased core body temperature. In a randomized single-blind study of 24 older patients who had general anesthesia during unilateral total knee arthroplasties, the use of forced-air warming during surgery reportedly prevented hypothermia after pneumatic tourniquet deflation.¹⁵

Acid-base effects

After a pneumatic tourniquet is deflated, the circulation of accumulated metabolic waste products from the extremity causes a mixed respiratory and metabolic acidosis.³ This process is characterized by increased PaCO₂, end-tidal carbon dioxide (ETCO₂), and serum potassium and lactate concentrations, and decreased PaO₂ and blood pH.³ These metabolic changes increase the patient’s minute ventilation and may induce arrhythmias. The time required for the patient’s body to clear accumulated metabolites depends on the patient’s physiologic status, the duration of pneumatic tourniquet inflation, and the volume of tissue affected.¹

Although the respiratory effects of acidosis are not clinically significant in many patients, evidence suggests that even a safe period of pneumatic tourniquet inflation (eg, one hour) can impair pulmonary gas exchange for several hours after tourniquet deflation.¹⁶ A randomized controlled trial evaluated the effects of one hour of pneumatic tourniquet inflation during unilateral lower extremity surgery.¹⁶ Study results indicated that six hours after pneumatic tourniquet deflation, patients had increased alveolar-arterial oxygen differences and respiratory indexes and decreased PaO₂ and arterial-alveolar oxygen tensions compared to controls who had no tourniquets used during surgery.¹⁶

Reperfusion injury

Ischemia-reperfusion injury comprises a group of local and systemic reactions triggered by the return of oxygenated blood to ischemic tissue. The pathophysiology is complex, and is partially mediated by oxidative stress from free radical damage, which can cause the death of cells already compromised by ischemia.¹,⁶,¹⁷ Local manifestations of ischemia-reperfusion injury include limb swelling and exacerbation of tissue injury, while systemic responses include myocardial effects that can progress to multiple organ failure and death.⁶

Ischemia-reperfusion triggers inflammatory changes that include complement activation, mast cell degranulation, neutrophil adhesion and infiltration, and microvascular dysfunction.¹⁵ Peroxidation of polyunsaturated fatty acids and the production of thiobarbiturate reactive substances further augment the inflammatory process.¹⁸ Whereas ischemia is marked by ATP depletion, acidosis, and ion imbalance, reperfusion causes an influx of cytokines, reactive oxygen species and calcium into skeletal muscle cells, which triggers unilateral cellular apoptosis and necrosis.¹³

Transient neutrophil and monocyte activation and increased neutrophil transendothelial migration can cause remote tissue injury.¹⁶ The local inflammatory response triggers muscle degeneration and swelling of the affected extremity, which may persist for up to six weeks after surgery.¹³

After prolonged ischemia (eg, 2 to 4 hours), tourniquet release is marked by compression-induced microvascular injury as well as endothelial injury from oxygen free radicals.⁴ This results in increased microvascular permeability in muscle and nervous tissue, which in turn causes interstitial and intracellular edema that can persist for one month and result in compartment syndrome.⁴

Skeletal muscle is highly susceptible to ischemia. Irreversible damage to muscle cells begins after three hours of ischemia and is almost complete at six hours.¹⁹ Because severity of cellular damage correlates directly with microvascular damage, sufficient tissue death leads to the cessation of microvascular flow, called the no-reflow phenomenon. This in turn causes tissue swelling to stop, limiting the extent of inflammation.¹⁹
Deep vein thrombosis and pulmonary embolism

Deep vein thrombosis (DVT) is an important potential complication of major surgery, particularly orthopedic lower limb surgeries such as total knee replacement. An estimated 40-60% of patients undergoing knee arthroplasty develop postoperative DVT. General anesthetics are vasodilators that increase the probability of blood pooling and clotting, which increases the likelihood of DVT. Other documented DVT risk factors include lower limb trauma, prolonged immobilization, prior history of DVT, malignancy, pregnancy or recent parturition, obesity, smoking, cardiovascular disease, and older age.

Deep venous thrombosis is of particular concern during surgery in general because patients are at risk of potentially fatal pulmonary embolization. In one large prospective cohort study of 4,211 patients with ultrasound-confirmed DVT, researchers analyzed risk factors for concurrent symptomatic pulmonary embolism. Significant independent risk factors included obesity (BMI >30 kg/m2), proximal DVT, chronic lung disease, and omission of DVT prophylaxis.

There has been debate about the extent to which pneumatic tourniquet use further increases the risk of postsurgical DVT. Pneumatic tourniquet use does not appear to be an independent risk factor for DVT. For example, in a study of 48 consecutive patients undergoing primarily total knee arthroplasty for osteoarthritis, researchers found no significant difference in the incidence of deep vein thrombosis among patients who had pneumatic tourniquet used during surgery compared to those who did not. However, because the overall rate of postoperative DVT among all patients was 81%, researchers emphasized the importance of prevention and early detection of DVT to prevent fatal pulmonary thromboembolism.

Results from another small study of nine total knee arthroplasty patients suggested that use of pneumatic tourniquets triggers local thrombogenic and fibrinolytic activity, as indicated by increases in the operative limb of prothrombin, plasmin-antiplasmin, and D-dimer. These increases did not affect the systemic circulation until local mediators from the injured limb were released following pneumatic tourniquet deflation.

Deep vein thrombosis also has been reported immediately following and within 30 minutes after exsanguination of the operative leg during lower limb surgery. Several cases of massive, fatal pulmonary emboli have been reported that occurred after the surgeon used an Esmarch bandage for intraoperative exsanguination of the affected limb. The surgeries included elective lower limb orthopedic surgeries such as total knee replacement, as well as surgery for lower limb trauma. Based on these data, researchers have concluded that exsanguination using an elastic wrap might not be appropriate in the case of patients with traumatic injuries, if the patient’s extremity has been immobilized in a cast, or if the patient has concurrent risk factors for DVT. Surgeons or anesthesia personnel, however, make the final decision as to whether to use an elastic wrap to achieve exsanguination.

**PRACTICE-SPECIFIC RISK FACTORS**

Studies have identified several practice-specific factors that can potentially increase the risk of local and systemic complications during and after surgery when pneumatic tourniquets are used. These include prolonged inflation time, excessive cuff pressure, and the use of narrower, non-contoured cuffs.

**Prolonged inflation time**

There is no indisputably safe pneumatic tourniquet inflation time during surgery. Therefore, pneumatic tourniquet time should be kept to a minimum. AORN further specifies that perioperative team members should regularly apprise surgeons of pneumatic tourniquet inflation time.

Longer pneumatic tourniquet time is directly correlated with an increased risk of tourniquet-related complications. In
studies, longer pneumatic tourniquet times (usually 2 to 3 hours) resulted in local and systemic effects such as decreases in core body temperature; metabolic disturbances; muscle damage; impaired renal, hepatic or pulmonary function; pain, and neuropathies. 

Prolonged pneumatic tourniquet inflation times have been found to increase the risk of postoperative complications after knee arthroplasty. In a prospective five-year study of 577 consecutive primary knee arthroplasties, 46 revision knee arthroplasties, and 18 patellar supplementing knee arthroplasties, pneumatic tourniquet inflation time of more than 100 minutes was associated with increased risk of post-surgical complications (odds ratio 2.4, 95% confidence interval 1.6-3.6) even after controlling for cuff pressure, age, sex, smoking status, American Society of Anesthesiologists (ASA) classification, diabetes status, and surgery indications.

A prospective randomized clinical study of 80 patients who underwent arthroscopic meniscectomy found no significant difference between the use of no pneumatic tourniquet and tourniquet times of less than 30 minutes in terms of the incidences of postoperative pain, muscle damage, or time to return to light work and jogging.

**Excessive cuff pressure**

Although tourniquet pressures vary in practice, standard settings have been reported as 300 mm Hg to 350 mm Hg in lower limbs and 200 mm Hg to 250 mm Hg in upper limbs. Excessive pneumatic tourniquet pressure increases the risk of postoperative complications, including tourniquet site pain; muscle weakness; compression injuries to nerves, blood vessels, muscle, or skin; wound complications; or extremity paralysis.

In a study of 164 patients on whom pneumatic tourniquets were used during total knee arthroplasty, researchers found that patients who had a cuff pressure of 225 mm Hg or lower had no postoperative infections and a lower rate of wound complications. In a related study, 20 total knee arthroplasty patients from the larger trial underwent electroneurography and qualitative sensory testing of thermal thresholds three days after surgery. Two months later, these tests were repeated and electromyography also was performed. The mean pneumatic tourniquet cuff pressure was 237 mm Hg (standard deviation), and the single case with electromyographic signs of denervation occurred in the patient who had the highest cuff pressure (294 mm Hg). Neurophysiologic examinations identified no differences between patients’ legs except decreased sensory nerve response amplitudes on the operated leg three days after surgery. The researchers concluded that risk of nerve injury is reduced when lower cuff pressures are used.

AORN recommends that inflation be kept to the minimum effective pressure as determined by the surgeon or anesthesia professional. This determination should be based on the patient’s limb circumference and the systolic blood pressure expected during surgery. Perioperative team members should also confirm the pressure setting to be used before inflating the cuff. Measuring limb occlusion pressure (LOP), which is the pneumatic pressure required to occlude arterial flow in the operative limb, can help reduce pneumatic tourniquet pressure levels and pressure gradients.

**Cuff width**

Cuff width also is another important aspect of pneumatic tourniquet safety. Using wider, contoured cuffs may decrease the risk of injury because there is less pressure on underlying tissue and lower pressure settings can be used. A study compared standard and wide thigh cuffs to determine the average pressure required to maintain an acceptable bloodless field. The results showed that standard cuffs required an average pressure of 242 mm Hg for 18 of 20 patients, while the wide cuffs required an average of only 202 mm Hg for 19 of 20 patients.

AORN specifies that the pneumatic tourniquet cuff should be as wide as possible without compromising exposure to the surgical site. Furthermore, contoured cuffs should be used when the width of the extremity tapers between the upper and lower edges of the cuff.
Intravenous regional anesthesia (also called a Bier block) is most commonly used on the upper extremities, but is also used on the lower limbs. Local anesthetics work by blocking voltage-gated sodium ion channels on neuronal axons. This reaction inhibits the formation and propagation of action potentials by reducing the sodium ion flux needed for depolarization in both cardiac and neural tissue.

The following procedures should be used when a pneumatic tourniquet is used in combination with intravenous regional anesthesia. After the insertion of an IV, the anesthesia professional exsanguinates the patient's operative limb and inflates the pneumatic cuff to confine a local anesthetic agent such as lidocaine within the extremity. Maximum recommended doses of lidocaine for intravenous regional anesthesia are 4 mg/kg in adults and 3 mg/kg in children. To help reduce pneumatic tourniquet pain or discomfort, a second distal cuff can be inflated, permitting the proximal cuff to be deflated without the anesthetic entering the central blood circulation.

Intravenous regional anesthesia is fast-acting and reliable and therefore may be preferred over general anesthetics.

However, local anesthetics have been associated with both cardiac and neural toxicity. The exact mechanism of local anesthetic systemic toxicity remains unclear, but toxicity can occur if high venous pressure causes leaking around the tourniquet or if the tourniquet fails, leading to an abrupt release of pressure and the instilled local anesthetic.

In either scenario, residual local anesthetic can rapidly enter the central bloodstream and travel to the heart and central nervous system. Because local anesthetic preparations typically affect the central nervous system when released into the circulation, early warning signs and symptoms of local anesthetic systemic toxicity manifest as neurological symptoms that may progress to seizures. However, in some patients, neurotoxicity primarily manifests as seizures. Cardiotoxicity is of particular concern and includes both indirect and direct components.

Careful monitoring of both the patient and cuff pressure is warranted during and immediately after intravenous regional anesthesia. In addition, perioperative nurses should screen the patient for sensitivities to local anesthetics and communicate with anesthesia personnel to confirm the plan for intravenous regional anesthesia before applying a pneumatic tourniquet.

Numerous studies and case reports point to patient-specific risk factors or contraindications for pneumatic tourniquet use and limb exsanguination. AORN specifies that the preoperative nursing assessment should include screening the patient for these potential contraindications, which include a history of:

- impaired circulation, peripheral vascular compromise, or other vascular abnormalities;
- venous thromboembolism;
• previous revascularization of the extremity;¹¹
• extremities with dialysis access (eg, arterio-venous grafts, fistulas);¹¹
• acidosis;³⁹
• hemoglobinopathy (eg, sickle cell anemia);⁴
• infection of the extremity;¹²
• tumor distal to the tourniquet;⁹
• hypertension or use of antihypertensives;⁴⁰
• use of supplements such as creatinine;⁴¹
• history of pain or weakness in the operative extremity, muscles, or bones;¹²-⁴³
• open fracture of the operative extremity; and
• increased intracranial pressure.¹³

SUMMARY
Pneumatic tourniquets help provide a bloodless field during extremity surgery and are used to help provide intravenous regional anesthesia. Although many patients undergo pneumatic tourniquet-assisted procedures without experiencing problems, pneumatic tourniquets remain controversial because of the risk of adverse outcomes such as peripheral nerve damage, DVT, compartment syndrome, increased postsurgical pain, and cutaneous injuries.

Potential risk factors for complications of pneumatic tourniquet use are diverse and practices that could increase risk of complications include use of prolonged pneumatic tourniquet time, excessive cuff pressure, and applying a cuff that is too narrow or does not fit snugly.

To prevent local and systemic complications of pneumatic tourniquet use, perioperative nurses should collaborate with surgeons and anesthesia professionals to address risk factors identified in the patient’s preoperative assessment and to monitor and respond to immediate and delayed adverse reactions.
REFERENCES


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1. The use of a pneumatic tourniquet during extremity surgery:
   a. Is a noncontroversial practice
   b. Requires effective communication and collaboration between nurses, anesthesia personnel, and the surgeon
   c. Is safe for all patients as long as tourniquet time does not exceed 30 minutes
   d. All of the above

2. Physiologic effects of exsanguination and pneumatic tourniquet inflation during surgery typically include all of the following EXCEPT:
   a. Increase in central venous pressure
   b. Increased heart rate
   c. Increased core body temperature
   d. Decreased core body temperature

3. Which of the following is NOT a common physiologic effect of pneumatic tourniquet deflation following a period of inflation during surgery?
   a. Hypotension
   b. Decreased heart rate
   c. Increased core body temperature
   d. Decreased core body temperature

4. The acid-base effects of pneumatic tourniquet deflation following a period of inflation are characterized by
   a. Elevated PaCO2 with respiratory acidosis and metabolic alkalosis
   b. Elevated PaCO2 with respiratory acidosis and metabolic acidosis
   c. Decreased PaCO2 with respiratory alkalosis and metabolic acidosis
   d. Decreased PaCO2 with respiratory alkalosis and metabolic alkalosis

5. A type of tissue in the extremities that is highly susceptible to ischemia is
   a. Skeletal muscle
   b. Nerves
   c. Bone
   d. Skin

6. A perioperative nurse is performing a preoperative assessment of a patient scheduled for total knee arthroplasty. Which of the following is NOT a primary contraindication for pneumatic tourniquet use?
   a. Significant vascular disease, including recent bypass, history of deep venous thrombosis, or impaired peripheral circulation
   b. Sickle cell anemia and other forms of hemoglobinopathy
   c. History of pain or weakness in the bones or muscles of the extremities
   d. History of ulcerative colitis

7. Select the FALSE statement about pneumatic tourniquet safety.
   a. Wider, contoured cuffs are generally safer than narrow cuffs because they require less pressure to achieve a near bloodless field
   b. Increased tourniquet time increases the risk of postoperative complications
   c. Narrow cuffs are generally safer than wide, contoured cuffs because they require less pressure to achieve a near bloodless field
   d. Increased cuff pressure increases the risk of postoperative complications
8. Choose the **FALSE** statement regarding intravenous regional anesthesia (Bier’s block).
   a. After a procedure is over, the perioperative nurse should leave the cuff fully inflated for at least 60 minutes
   b. Intermittently deflating and reinflating the cuff for several cycles after the procedure is over may help minimize peak blood concentration of the local anesthetic and reduce the risk of a systemic toxic reaction
   c. Central nervous system abnormalities are usually the earliest warning signs of a systemic toxic reaction during intravenous regional anesthesia
   d. Before applying a pneumatic tourniquet, nurses should screen patients for sensitivities to local anesthetics and communicate with the anesthesia professional to confirm the plan for intravenous regional anesthesia

9. Choose the extremity and nerve most frequently affected by pneumatic tourniquet-induced nerve damage.
   a. Lower limb, peroneal nerve
   b. Upper limb, radial nerve
   c. Upper limb, median nerve
   d. Upper limb, ulnar nerve

10. A perioperative nurse is assessing patients for DVT risk factors prior to lower limb surgeries. Based on the following descriptions, which patient **DOES NOT** have risk factor(s) for DVT?
    a. A 35-year-old patient on prolonged bed rest
    b. A 70-year-old smoker with no history of significant medical problems
    c. An obese 45-year-old who is otherwise healthy
    d. A 20-year-old non-smoking athlete with a left anterior cruciate ligament tear
POST-TEST ANSWERS
PATHOPHYSIOLOGY AND RISKS OF PNEUMATIC Tourniquet USE

1. b
2. d
3. c
4. b
5. a
6. d
7. c
8. a
9. b
10. d

1. a
2. b
3. c
4. b
5. a
6. d
7. c
8. a
9. b
10. d