LOWER LIMB FASCIOTOMY

Emergency Alleviation of Compartment Syndrome

Curriculum for two-incision, four-compartment Fasciotomy

Training Package curated by:
Theepica Jeyarajah, MS[1]; Mark Bowyer, MD[2]; Tyler Harris, MD[3]; Brian Milam, MD[3]; Joseph Lopreiato, MD, MPH[2]

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TRAINING DOCUMENTS

INSTRUCTOR

STUDENTS

Table of Contents

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INSTRUCTOR DOCUMENTS

Placeholder for Infographics 1

Subject Matter Expert/Instructor Roles and Responsibilites 3

Fasciotomy Training Event Flow and Training Locations (Fillable Sheet) 5

Training Set-Up Suggestions 6

Presentation 7

Fasciotomy Knowledge Assessment Answer Key 16

Fasciotomy Evaluation Checklist 18

STUDENT DOCUMENTS

Presentation with Notes 22

Fasciotomy Knowledge Assessment 39

Fasciotomy Practice Procedural Checklist 41

Fasciotomy Refresher Tools 43

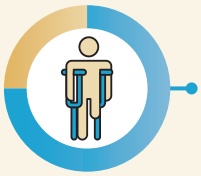
References & Award Information 44

Congratulations! You are about to lead a training on a limb and life-saving procedure, the two-incision, four-compartment lower limb Fasciotomy.

This is a comprehensive guide that includes all documentation needed for both you, the instructor, as well as students. Pay special attention to the pages in this training booklet, they are noted as **"Instructor Documents"** and **"Student Documents"**. Each section includes its own set of documentation that will be used throughout the training. You are encouraged to look through the pages before leading a training session. Additionally, this package includes a comprehensively narrated *Curriculum presentation* – play this presentation at the beginning of the training to give students a broad overview of Compartment Syndrome (CS) and the lower limb fasciotomy procedure. The PowerPoint is self-narrated – you may pause the presentation at any time to ensure all students can take notes or ask questions. All information in the presentation will provide the students ample knowledge to succeed in this training. Supplemental refresher tools, such as the Fasciotomy application (for Android and Apple devices) and the Fasciotomy Refresher Booklet, the DASH-1 (Printable) are available to students after the training to stay refreshed on essential information from the training.

Compartment Syndrome (CS)

is a limb-threatening and potentially life-threatening condition. The definitive treatment of compartment syndrome is **early and aggressive fasciotomy.**[2]



A study reported **75%** of amputations of the lower extremity were related to a delay in performing, or performing an incomplete fasciotomy.[3]

Burns, crush injury, bleeding in enclosed spaces, external compression of the limb, and blast injury have all been reported to cause compartment syndrome of the lower extremity.[4]

Treatment in a timely manner is necessary. The longer treatment is delayed irreversible damage will occur due to increased pressure within the compartments.[1,5]

Feasibility of performing fasciotomy in the early en-route care environment by both traditional and non-traditional providers is required to ensure that our wounded heroes receive the best care possible[6]

A Mastery Learning model allows learners to practice with coaching as many times as needed to reach competence.

POWERED BY VALIDATION DATA:

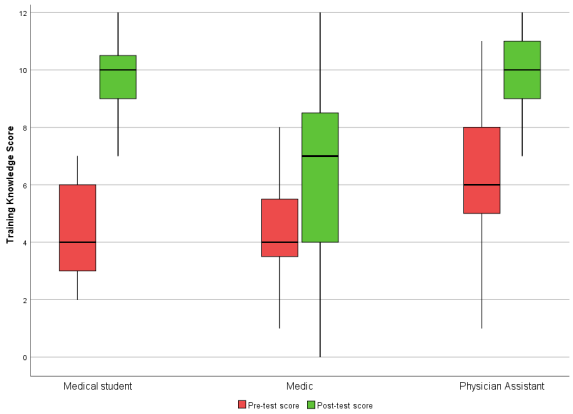


Figure 1 The graph displays Medical Student, Medic, and Physician Assistant learners' knowledge and performance scores at baseline (before training) and after training. All learner groups display an increase in score after taking this training.

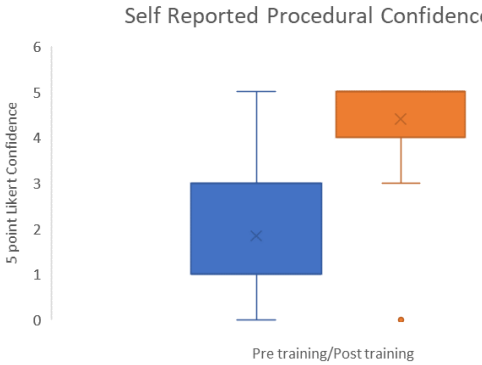


Figure 2 The graph displays confidence in learners before (blue) and after (orange) training. Learners generally reported higher levels of confidence in knowledge and skill after taking the training.

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Training Documents

INSTRUCTOR

Subject Matter Expert/Instructor Roles and Responsibilites

Uniformed Services University

GETTING STARTED: INSTRUCTOR ROLES AND RESPONSIBILITIES

Use this Roles and Responsibilities Worksheet to guide each phase of the Fasciotomy Training. The Instructor will provide guidance, mentor hands-on training, and evaluate learners, preferably in an austere medical environment. The bolded items refer to documents included in this training package – use the respective documents needed in each phase of the training outlined below.

Pre-Training Preparation - Consider the following questions to guide your training preparation:

- How many students will attend a training session? Based on the total number of students who plan to attend, training areas should be configured and optimized to support this number.
- How many instructors can support the training? This can significantly change total throughput during the testing phase, which must be completed one-on-one (one trainer to one student). Consider our "Good, Better, Best" ratios of trainers to students for the Hands on Training Phase, based on total student count.

Good: 1 Trainer to 6 students, **Better:** 1 Trainer to 4 Students, ★ **Best:** 1 Trainer to 1 or 2 students

- How can the training space be optimized for the course? Depending on what room(s) are available, consider having distinct spaces for Introductions & Didactics, Hands on Training, and Testing Phases. If space is limited, consider prioritizing a separate, austere testing environment for the final evaluation phase.

Phase 1 - INTRODUCTIONS & DIDACTICS: Once students have been directed to the training room/station, the Instructor can begin training.

- Prepare learning materials - Print a copy of the **Instructor Materials** for yourself and adequate copies of the **Student Materials** for each student.
- Play the **Fasciotomy PowerPoint** - This is a fully narrated presentation. You can pause at any time to take questions or to reinforce a point - all critical information is included in the narration. You may use the **Instructor Notes** Page for your reference if need be. Encourage students to take notes on the **Student Notes** pages and ask clarifying questions as needed.
  NOTE: The presentation contains graphic images of leg injuries – please review the slideshow beforehand, and make students aware of this prior to initiating training.
- An optional **Knowledge Assessment** can be administered after the PowerPoint presentation. You may elect to review answers with students. **The Knowledge Test Answer Key** is provided in your instructor materials.
- This should take ~30 minutes to complete.

Phase 2 - HANDS ON TRAINING: After the Didactic Phase, consider moving to a different space with pre-set stations to start the Hands-on Training Phase.

- Set up stations with Fasciotomy Task Trainers and all surgical equipment needed.

Equipment List:

- 1 Scalpel
- 1 Metzenbaum scissors
- 2 Self-Retaining Retractors
- 1 Rat tooth tweezer
- 1 Sharpie

  - Review equipment list with students all necessary equipment to perform the fasciotomy. (See **Training Set Up Suggestions**)
- Introduce the Fasciotomy Simulator/Task Trainer
  - Demonstrate proper identification of anatomical landmarks on both the lateral and medial sides of the model and how to use the simulator. Emphasize how to use landmarks as a guide to create your incision lines.
- Demonstrate the full procedure:
  - Review proper usage and safety mechanisms of all surgical tools.
  - Using the **Fasciotomy Procedural Checklist**, the instructor will read aloud each step while demonstrating it in real time on the simulator.
  - The instructor can choose a volunteer student, and read the checklist step-by-step while the student completes the procedure in real time and demonstrates it to the rest of the class.
  - Answer questions from students as needed.
  - This should take ~25 minutes to complete. Then have class split into pairs or individuals for hands-on training (Depending on group size).

- Practice in small groups using the Mastery Learning Model
  - At each training station, have a simulator, surgical tools, and Fasciotomy procedural checklist at the ready. Students may run through the entire procedure using the checklist at each table.
  - Students should practice all steps in the procedure, using a stopwatch or timer.
  - Have each student review the steps they completed on the **Fasciotomy Checklist** in order to determine their practice fasciotomy score for each attempt.
  - The instructor can move about the practice and provide feedback to each small group or pair.
  - Students are ready to test out once the instructor has seen a successful practice attempt completed by the student.
  - On average, most students will need to complete the procedure with a passing Fasciotomy score (no critical steps missed, full release of fascia attainted).
  - This training phase can take anywhere from ~30 minutes to an hour depending on the learner and class size.

Phase 3 - SUMMATIVE EVAULATION: In the austere testing environment, prepare to evaluate students.

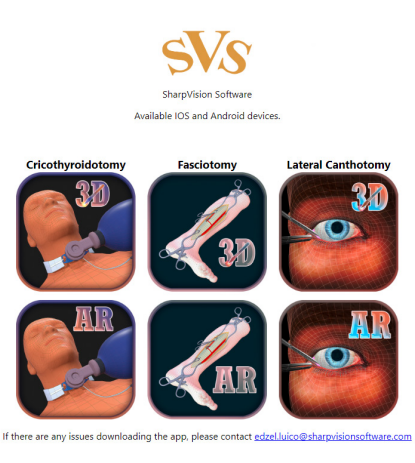
- Set up the Fasciotomy Simulator in an austere environment or training lane (see Training Set-up Suggestions).
- Evaluate student performance using the **Fasciotomy Evaluation Checklist** and a timer.
- Do not provide feedback during the test out.
- A passing performance is defined as successful completion of the procedure (full release of the compartment) and all critical items on the Procedural Checklist.
- Provide feedback following completion of procedure, and retest if necessary.

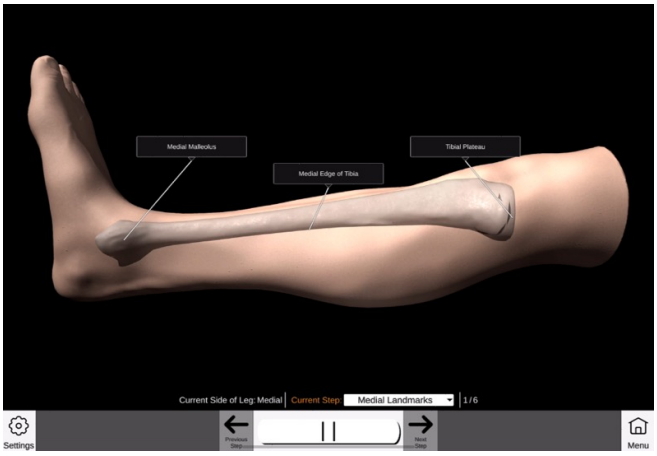
Phase 4 - DEBRIEF

- Review performance and provide suggestions to students as needed
- Pay special attention to common procedural pitfalls that a student may make during the procedure. Ensure that these pitfalls are remediated with explanation as to why such errors can be dangerous. (See Slide 50 in the Fasciotomy powerpoint)

NEW! Post Training - Suggested Refresher Tools

- Virtual Reality Fasciotomy Application (Android/Apple) is available here:
  iOS: **http://battlefieldarassist.us/**
  Android: **https://drive.google.com/drive/folders/1dlW-91rve8iKvMKYuSZjhBB4t1MJ298O**.
  - After completing training, this application can be used to refresh students on the fasciotomy procedure.
  - Students can use the application in the future to refresh their knowledge on Fasciotomy.
- Printable Fasciotomy Procedural Booklet – DASH-1
  - Students can keep the booklet for quick access to review fasciotomy steps.





Event Flow and Training Locations (Fillable Sheet)

EVENT FLOW AND TRAINING LOCATIONS

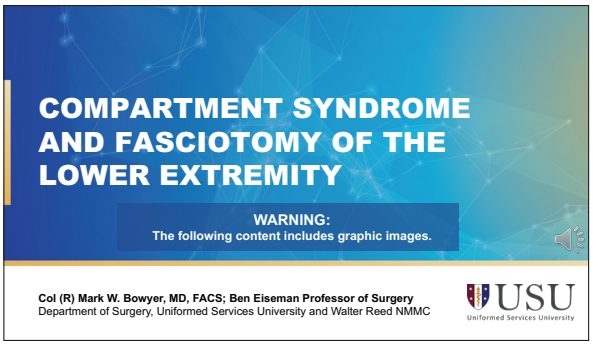
Instructions: Use this Fillable Worksheet to assist in planning your training. You may want to designate spaces based on the Sub-Components of each training phase detailed below.

Phases	Sub-Components	Room Location (Fill-In)
Introduction	• Introductions and Housekeeping • Review of Training • Review of Student expectations	
Phase 1: Didactic Training	• PowerPoint Curriculum Presentation • Knowledge Test and Review of Answers (Optional)	
Phase 2: Hands on Training	• Surgical Equipment Review • Demo of Fasciotomy on task trainer by SME/Instructor and Checklist Review • Mentored practice on model • Trainees can ask questions before evaluation	
Phase 3: Summative Evaluation	• Fasciotomy Testing (In a testing environment) • If trainee fails, provide extensive review with PowerPoint and Checklist • Allow student to retest	
Phase 4: Debriefing	• Debrief student on their performance, provide suggestions as needed • Ask for students training feedback to improve future sessions	

Additional components:	Room Location
Independent study	
Breaks	

A. *An instructor demonstrates the fasciotomy procedure by first showing the student how to properly identify landmarks and mark the leg prior to incision.* ***B.*** *Hands-On Training - Multiple stations are set up for students to practice the procedure. Each station is equipped with the tools needed to learn how to perform the fasciotomy (Task trainer by Operative Experience Inc). Students are encouraged to recite each step of the procedure as they do it, and mark their progress on the practice log.* ***C.*** *and* ***D.*** *An example of an austere environment used for the Summative Evaluation phase.* ***E.*** *The instructor moves through the demonstration phase of the training and reviews tools, steps, and best practices to complete the procedure successfully.*

Instructions: Here is a preview of the slides in the PowerPoint Presentation. The PowerPoint is self-narrated – you may pause the presentation at any time to ensure all students can take notes or ask questions.



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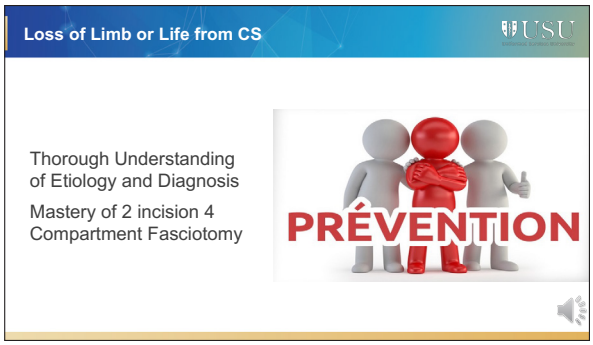

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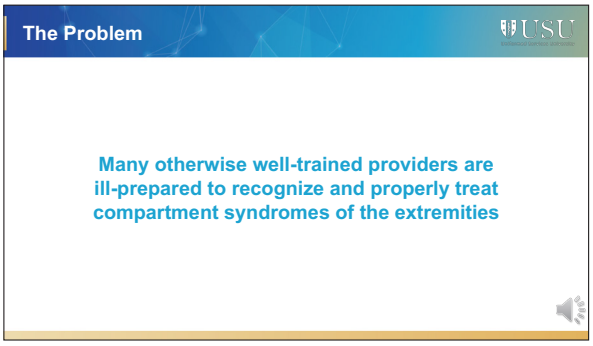

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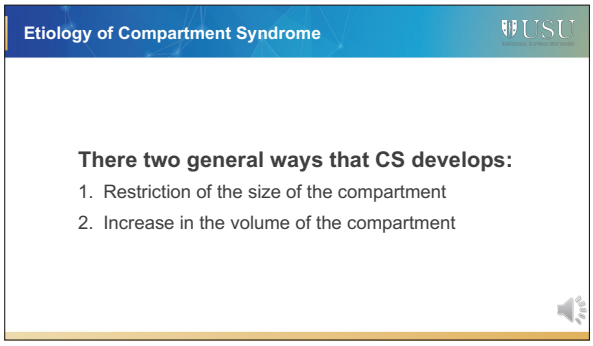

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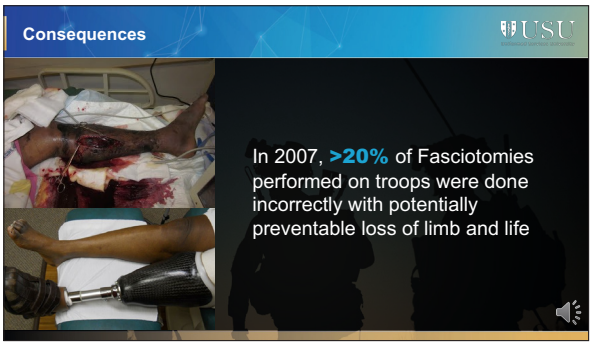

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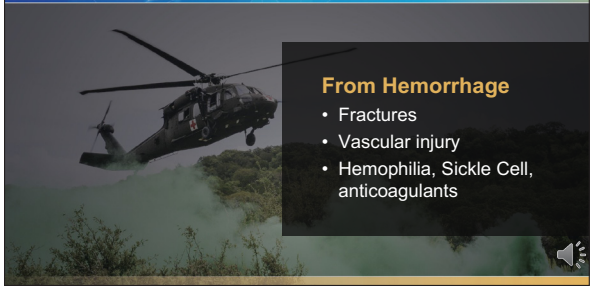
Increased Compartment Volume



From Hemorrhage

- Fractures
- Vascular injury
- Hemophilia, Sickle Cell, anticoagulants

7

Increased Compartment Volume

From Muscle Edema/Swelling

- Crush-trauma, drugs, alcohol
- Electrical Burns
- IO infusion/massive resuscitation
- Rhabdomyolysis/Blast
- Bee stings/Snake bites
- Sepsis, reperfusion injury
- Exercise induced
- Postpartum eclampsia

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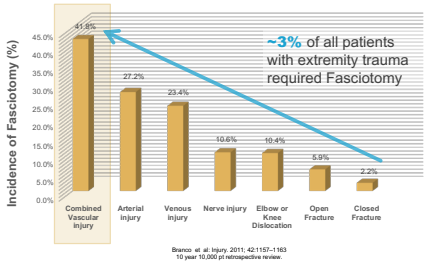
Incidence of Fasciotomy (%)



Branco et al. Injury. 2011; 42:1157–1163
10 year 10,000 pt retrospective review.

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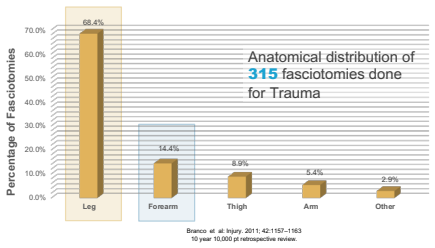
Percentage of Fasciotomies



Branco et al. Injury. 2011; 42:1157–1163
10 year 10,000 pt retrospective review.

10

Diagnosis

The diagnosis of CS requires **high index of suspicion** and recognition of subtle physical exam findings.

It is important to recognize and treat CS before irreversible cell damage occurs

11

Diagnosis - Classic Signs/Symptoms

The Five P's

- Pain
- Pallor
- Paresthesias
- Paralysis
- Pulselessness

The most important symptom of CS is pain greater than expected due to the injury alone.

12

Measurement of Compartment Pressures

- May be of value when exam is unreliable
- Commercial device or needle to arterial line transducer
- Pressure > 30 mm Hg or a Δp (diastolic BP – Comp. Press) < 30 is threshold for Dx of CS

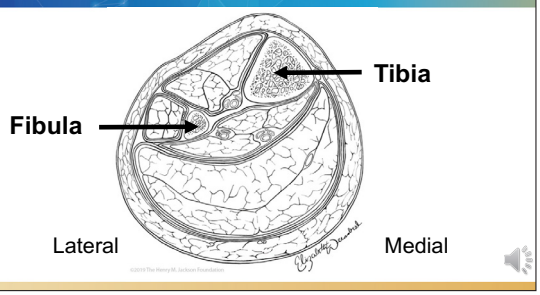
13

Fasciotomy of the Lower Leg

- The treatment of lower leg CS is prompt & proper Fasciotomy.
- Two Incision Four Compartment Fasciotomy is the standard in trauma.
- Must know the anatomy to do this correctly!

14

Cross Section of Lower Leg



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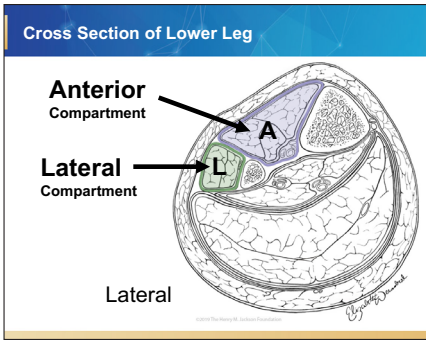
Cross Section of Lower Leg



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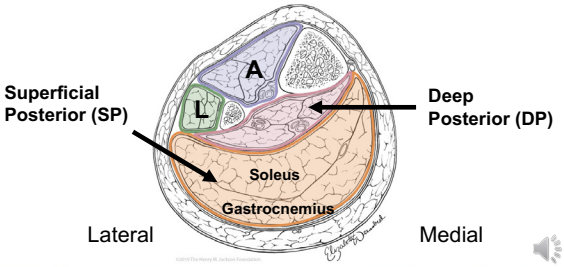
Cross Section of Lower Leg



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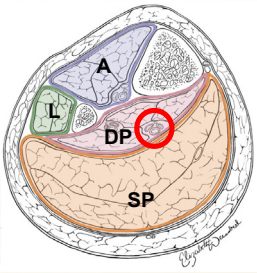
Cross Section of Lower Leg



Identification of the posterior tibial neurovascular bundle confirms entry into the deep posterior compartment

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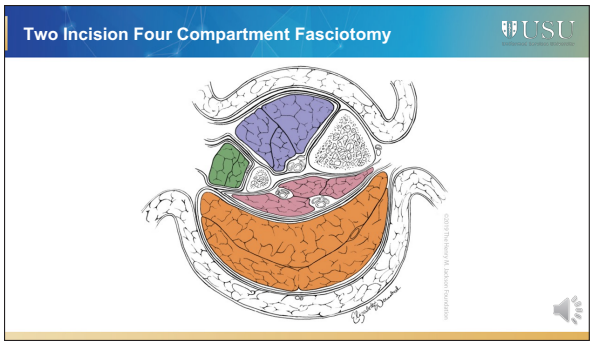

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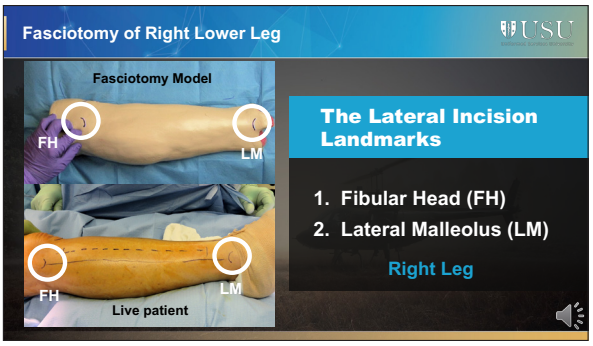

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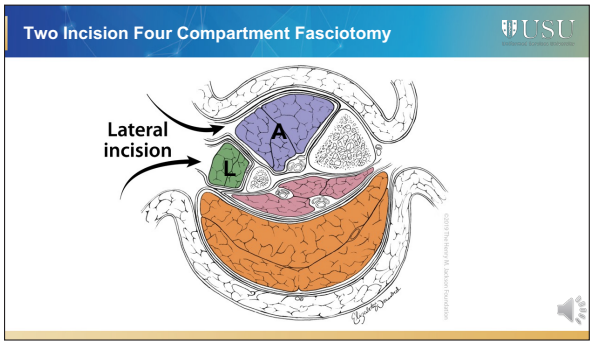

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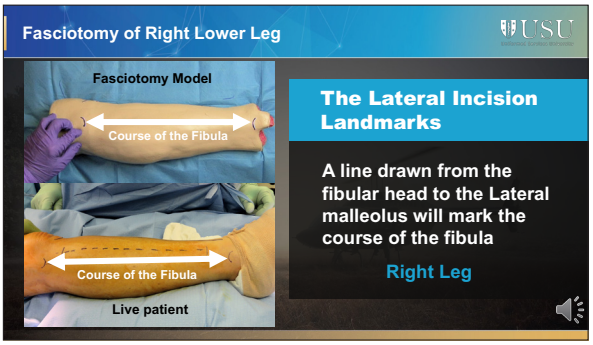

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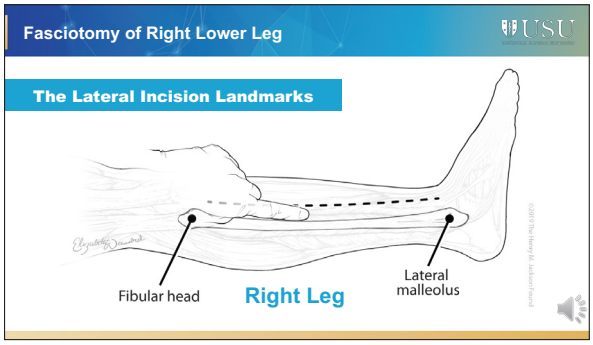

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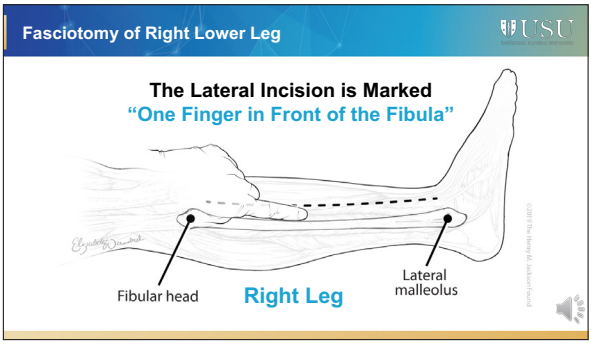

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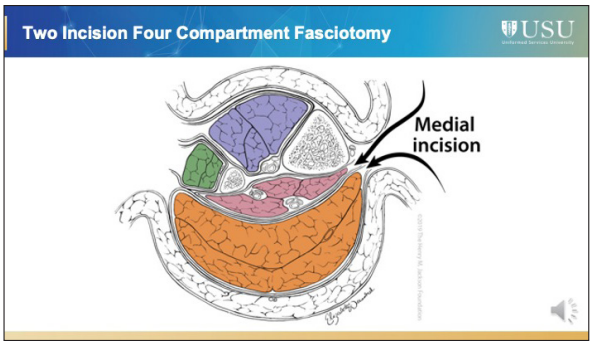

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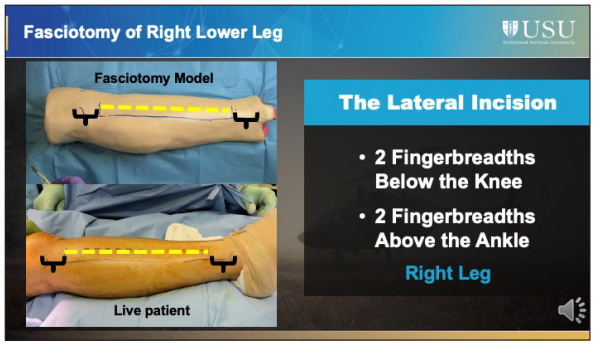

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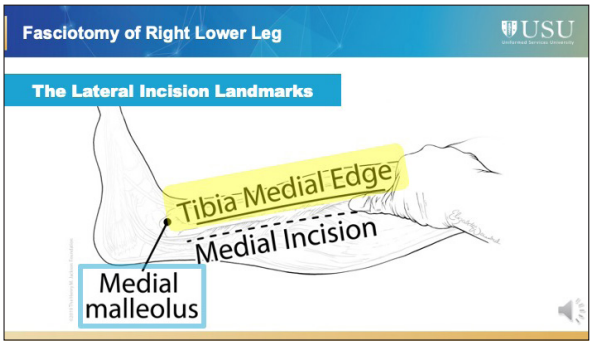

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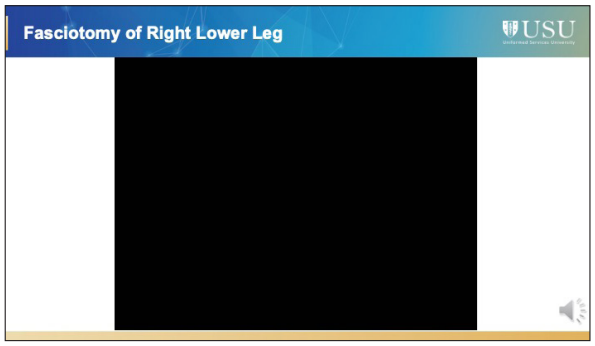

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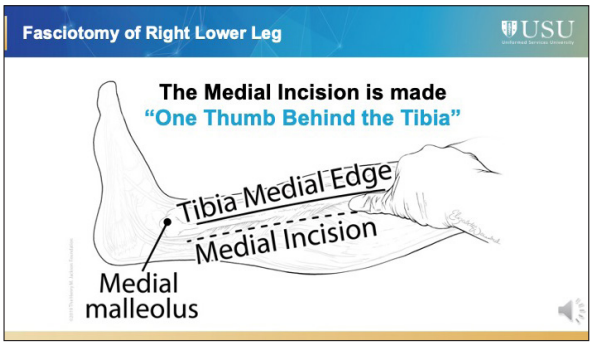

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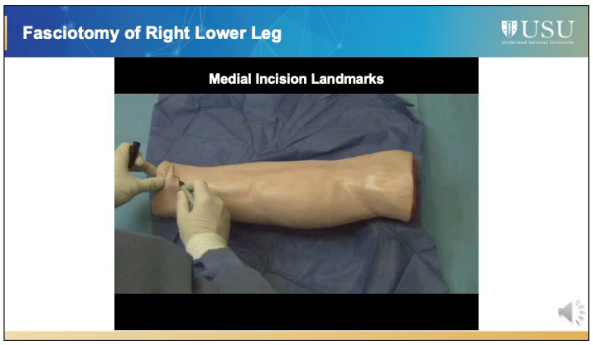

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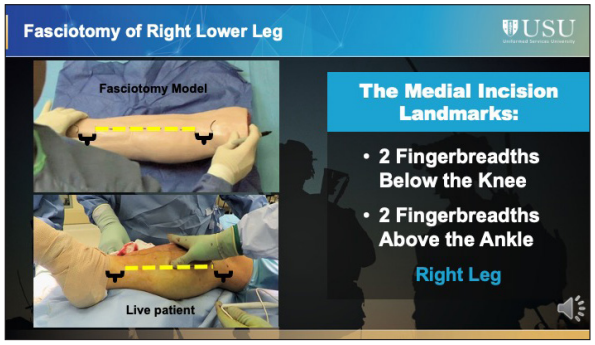

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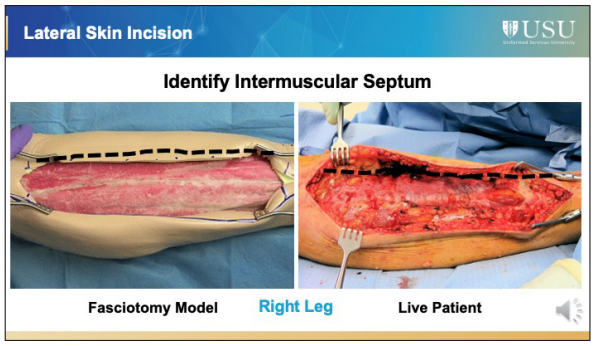

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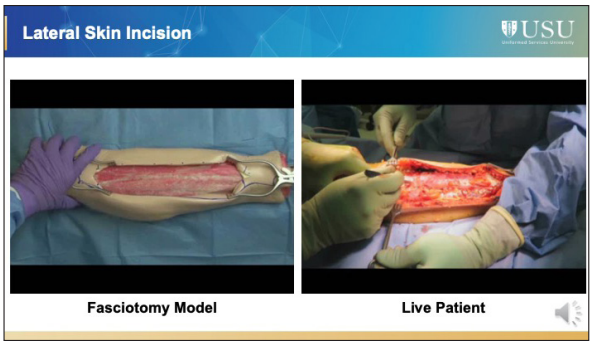

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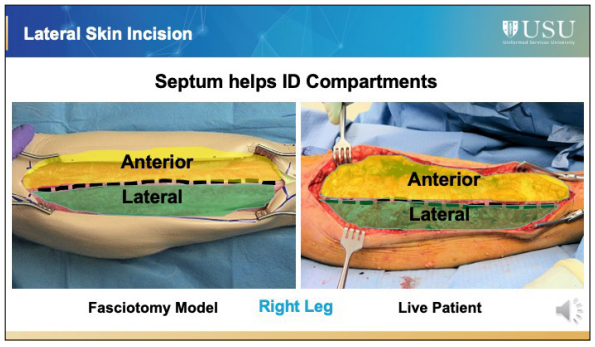

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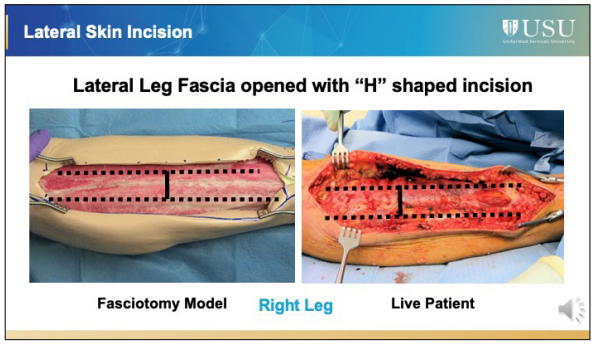

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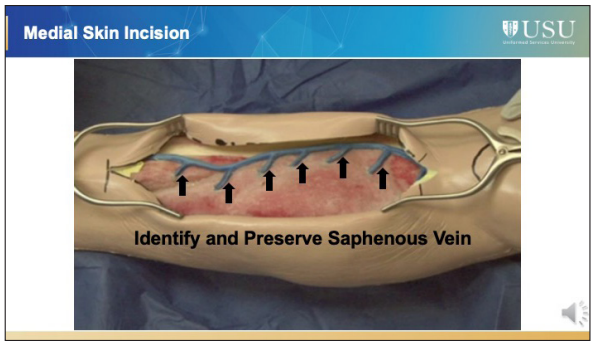

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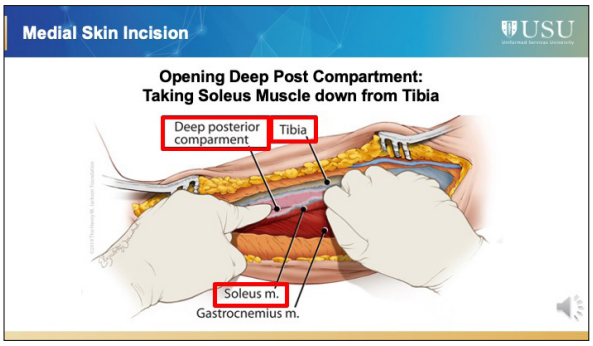

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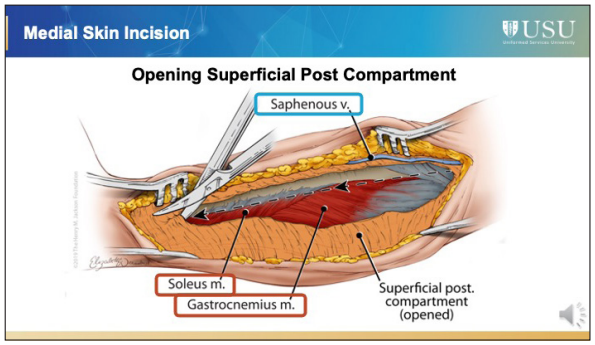
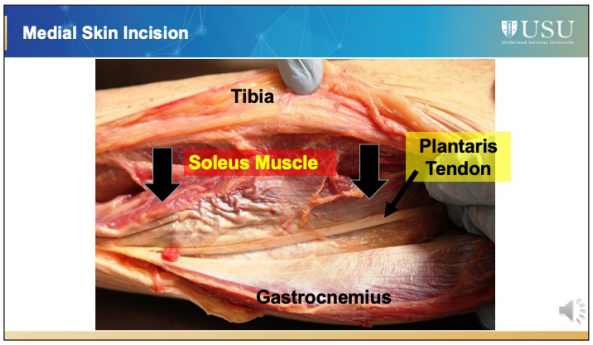


44



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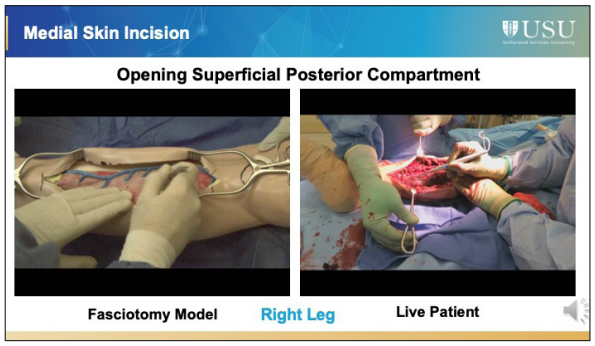
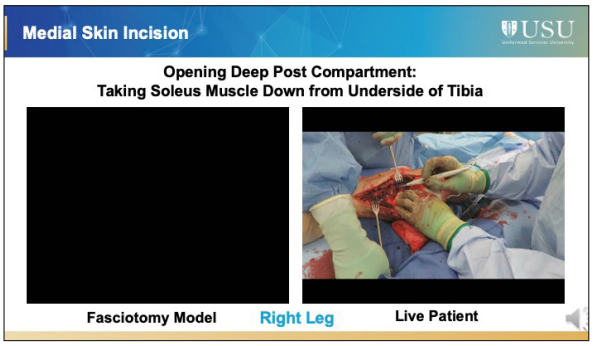


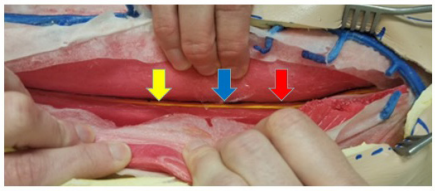
45



48

Medial Skin Incision

Identification of the Posterior Tibial Neurovascular Bundle Confirms Entry into Deep Posterior Compartment



Fasciotomy Model

49

Potential Pitfalls

- **Failure to identify the need for fasciotomy**
- **Failure to make adequate skin incisions**
  - Skin can act as a constricting bridge
- **Damage to underlying structures**
  - Superficial Peroneal nerve (Lateral Leg)
  - Saphenous Vein (Medial Leg)
- **Missing a compartment**
  - Anterior compartment most frequently missed
  - Deep Posterior compartment 2nd most frequently missed

50

Summary

- CS must be suspected in all polytrauma patients with extremity injury.
- All clinicians should have intimate knowledge of the etiology, diagnosis, and treatment.
- A High index of suspicion should be maintained
- Two Incision Four Compartment Fasciotomy is the standard in trauma, and understanding the anatomy is essential to performing this procedure correctly

51

Fasciotomy Knowledge Assessment Answer Key

Uniformed Services University

Instructions: Assess your knowledge on Fasciotomy using this quiz.

Please circle the correct answer.

1. All of the following statements regarding the development of compartment syndrome (CS) of the extremities are true, except:
   a. Compartment syndrome can develop from muscle overuse.
   b. Patients with hypotension are less likely to develop CS due to decreased flow.
   c. Open fractures of the lower extremity are less likely to develop CS than closed fractures.
   d. Evenomation (snake bite) can lead to the development of CS.

2. The Pathophysiology of CS is related to all of the following mechanisms except?
   a. Reduction in the volume of the compartment – constrictive dressing.
   b. Impairment of the sodium channel pump in the nerve cell wall.
   c. Increase in the volume of the compartment.
   d. Reperfusion of the compartment after interruption of vascular flow.

3. Which of the following is the most sensitive early symptom or physical finding suggesting the diagnosis of lower extremity CS?
   a. Parathesias (numbness) of the foot.
   b. Loss of pulses in the lower extremities.
   c. Pain greater than expected due to the injury alone.
   d. Pallor of the lower extremity compared to the unaffected limb.

4. Which of the following injuries is most likely to be associated with a compartment syndrome?
   a. A dislocation of the knee.
   b. An open fracture of the tibia.
   c. A closed fracture of the tibia and fibula.
   d. A gunshot wound with injury to both the popliteal artery and vein.

5. In patients with an unreliable exam, measurement of compartment pressures may help to make the diagnosis of compartment syndrome. Which of the following measurements suggest that a compartment syndrome may be present?
   a. A delta pressure difference in pressure of less than 30 mm Hg.
   b. A compartment pressure greater than 20 mm Hg.
   c. A delta pressure difference in pressure of greater than 40 mm Hg.
   d. A compartment pressure less than 30 mm Hg.

6. The lateral aspect of the lower leg contains which of the following compartments?
   a. The superior and lateral compartments.
   b. The lateral and anterior compartments.
   c. The anterior and posterior compartments.
   d. The lateral and inferior compartments.

7. In the swollen extremity, the intramuscular septum on the lateral leg may be difficult to identify. Which of the following structures will best aid in the initial identification of the septum?
   a. The fibular head.
   b. The deep peroneal nerve.
   c. The perforating vessels.
   d. The lower edge of the tibia.

8. Compartment syndrome is most likely to occur in which decreasing order of frequency?
   a. Thigh > lower leg > upper arm> forearm.
   b. Thigh > upper arm > lower leg > forearm.
   c. Lower leg > thigh > forearm > upper arm.
   d. Lower leg >forearm > thigh > upper arm

9. The ideal placement of the medial incision when performing a two incision four compartment fasciotomy is?
   a. A "thumb" behind or below the palpable edge of the tibia.
   b. Directly over the course of the saphenous vein.
   c. Directly below the palpable edge of the tibia.
   d. Four finger breadths from the anterior tibial spine

10. The compartment in the lower extremity that is most susceptible to developing CS?
    a. Lateral
    b. Superficial Posterior
    c. Medial
    d. Anterior
    e. Deep Posterior
    f. Inferior

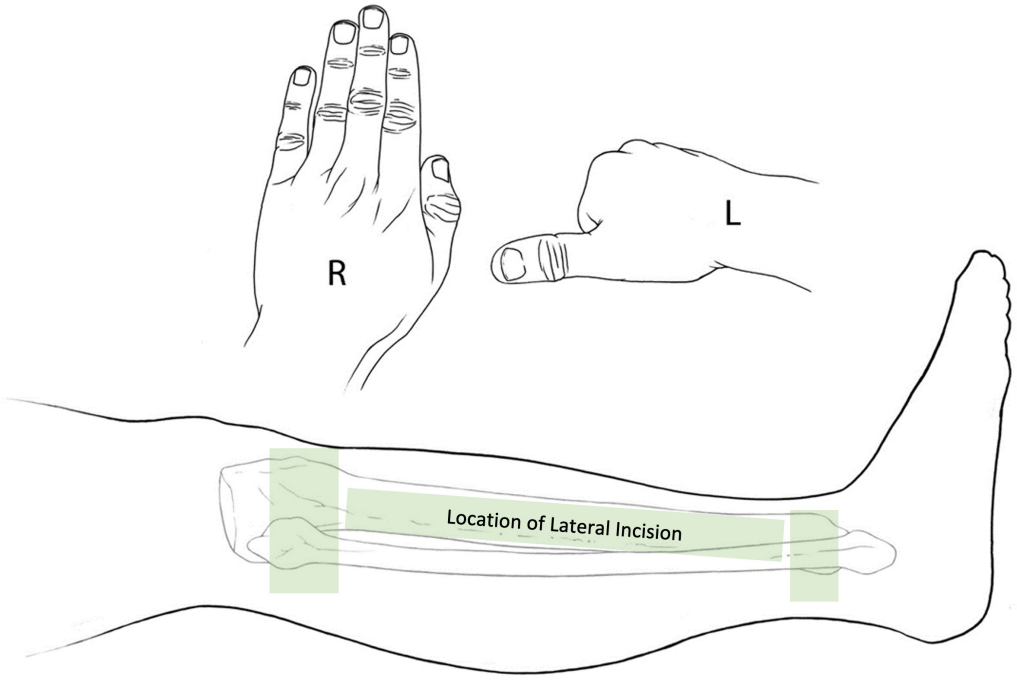
11. Iatrogenic injury to the superficial peroneal nerve is most likely to occur when opening which compartment?
    a. Anterior
    b. Lateral
    c. Superficial Posterior.
    d. Deep Posterior
    e. Medial
    f. Superior

12. The posterior tibial artery is in which compartment?
    a. Superior
    b. Anterior
    c. Lateral
    d. Superficial Posterior
    e. Deep Posterior
    f. Medial

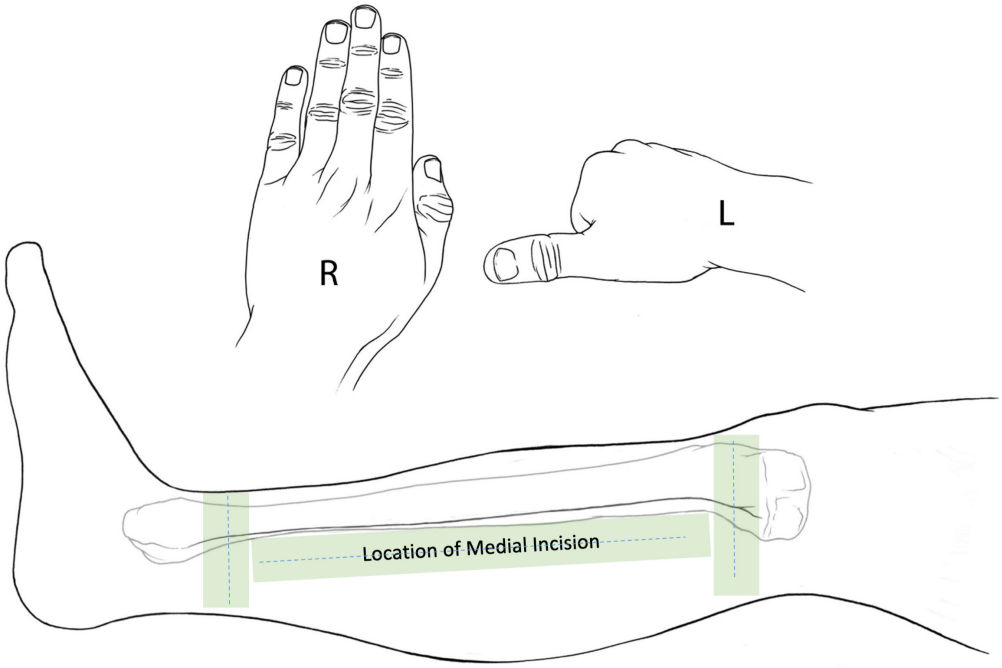
13. The soleus muscle is in which compartment?
    a. Deep Posterior
    b. Anterior
    c. Lateral
    d. Superficial Posterior
    e. Medial
    f. Superior

END OF THE INSTRUCTOR TRAINING GUIDE

14. Please draw on the image below the ideal skin incision for performing the lateral incision of the lower leg for a fasciotomy. The hands and fingers are included to help judge relative scale?



15. Please draw on the image below the ideal skin incision for performing the medial incision of the lower leg for a fasciotomy.



Fasciotomy Evaluation Checklist

Uniformed Services University

Evaluator Instructions: Use the procedural checklist below to assess students during the Summative Evaluation phase. If critical steps are not completed correctly, the attempt should be scored as a failed attempt – have students re-attempt until proficiency is met.

Lateral Skin Incision Marking	Skill Met		Grader Notes
Marks head of fibula proximally	P	F	
Marks lateral malleolus at ankle	P	F	
Marks the course of the fibula	P	F	
Marks incision one finger in front of the fibula (1.5 - 2.5 cm)	P	F	
Marks upper end of incision 2-3 fingers (3.0 - 5.0 cm) below the knee	P	F	
Marks lower end of incision 2-3 fingers (3.0 - 5.0 cm) from the Lat. Malleolus (above ankle)	P	F	
Lateral Skin Incision Marking Score (6 points):			

Medial Skin Incision Marking	Skill Met		Grader Notes
Marks medial aspect of tibial plateau	P	F	
Marks medial malleolus	P	F	
Marks length of medial edge of tibia	P	F	
Marks incision line one thumb behind tibia	P	F	
Marks upper end of incision 2-3 fingers (3.0 - 5.0 cm) from Tibial Plateau (TP)	P	F	
Marks lower end of incision 2-3 fingers (3.0 - 5.0 cm) from the Med Malleolus	P	F	
Medial Skin Incision Marking Score (6 points):			

Lateral Fasciotomy	Skill Met		Grader Notes
Verbalizes/Identfies the correct location of the septum	P	F	
Make vertical portion of H shaped incision first across the septum (may pass if wrong septum)	P	F	
Underruns fascia with closed scissors tips prior to opening fascia	P	F	
Opens fascia with partially closed scissor tips (in a pushing method)	P	F	
Points tips of scissors away from the septum in lateral compartment distally	P	F	
Lateral Fasciotomy Score (5 points):			

Medial Fasciotomy	Skill Met		Grader Notes
Verbally identifies and does not injure greater saphenous vein	P	F	
Takes down the soleus bridge from the tibia to expose the deep posterior compartment	P	F	
Demonstrates that the Posterior tibial neurovascular bundle is visible in the deep compartment	P	F	
Medial Fasciotomy Score (3 points):			
Total Time of procedure:	_____:_____ (min) (sec)		Time of procedure from first incision to subject verbalizes DONE
Section 1 Score (20 points)			
Performance Complete			

LATERAL Incisions and Fasciotomies

Lateral Skin Incision	Points	Grader Notes
Makes the lateral skin incision (location)…		
… one finger in front of the fibula (1.5 - 2.5 cm)	3	
… 2.5 - 4.0 cm in front of fibula	2	
… 0 - 1.5 cm in front of the fibula	1	
… directly over fibula or behind the fibula	0	
Upper End of lateral skin incision is (length of incision)…		
...2-3 fingers (3.0 - 5.0 cm) from inferior patella	3	
…Less than 3.0 cm from inferior patella	2	
…5.0 - 8.0 cm from the inferior patella	1	
...> 8.0 cm from the inferior patella	0	
Lower end of the lateral skin incision is (length of incision)…		
...2-3 fingers (3.0 - 5.0 cm) from the Lat. Malleolus	3	
...Less than 3.0 cm from Lat. malleolus	2	
...5.0 - 8.0 cm from the Lat. malleolus	1	
...> 8.0 cm from the Lat. Malleolus	0	
Lateral Skin Incision Score (9 points):		

** CRITICAL: Lateral Fasciotomies	Skill Met		Grader Notes
****Opens fascia in lateral compartment, ≥ 3.0 -5.0 cm from the inferior patella and lateral malleolus**	**P**	**F**	
****Opens fascia in anterior compartment, ≥ 3.0 -5.0 cm from the inferior patella and lateral malleolus**	**P**	**F**	
Lateral/Anterior Fasciotomy Score (2 points):			

MEDIAL Incisions and Fasciotomies

Medial Skin Incision	Points	Grader Notes
Made the Medial skin incision (location)…		
… one thumb behind tibia (2.0 - 3.0 cm)	3	
… 1.0 - 2.0 cm behind the tibia	2	
… 1 - 1.0 cm behind the tibia	1	
… at the edge or anterior to the edge of the tibia	0	
Upper End of Medial skin incision is (length of incision)…		
… is 2 - 3 fingers (3.0 - 5.0 cm) from tibial plateau (TP)	3	
… Less than 3.0 cm from TP	2	
… 5.0 - 8.0 cm from the TP	1	
… > 8.0 cm from the TP	0	
Lower end of the Medial skin incision is (length of incision)…		
… is 2-3 fingers (3.0 - 5.0 cm) from the Med. Malleolus	3	
… Less than 3.0 cm from Med. Malleolus	2	
… 5.0 - 8.0 cm from the Med. Malleolus	1	
… > 8.0 cm from the Med. Malleolus	0	
Medial Skin Incision Score (9 points):		

** CRITICAL: Medial Fasciotomies	Skill Met		Grader Notes
****Opens fascia over the superficial compartment ≥ 3.0 - 5.0 cm from the TP and the Medial Malleolus**	P	F	
****Opens the fascia over the deep posterior compartment ≥ 3.0 - 5.0 cm from the TP and the Medial Malleolus**	P	F	
Medial Fasciotomy Score (2 points):			
Section 2 Score (22 points)			
Performance Evaluation Complete			

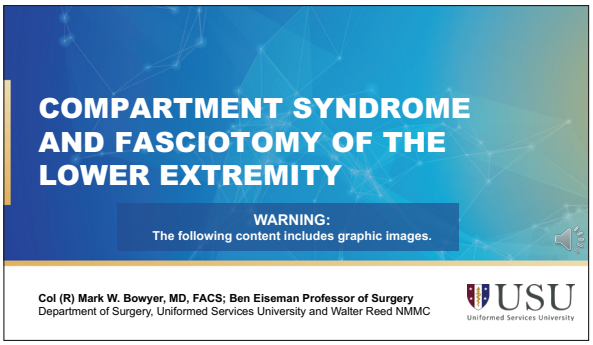
FINAL SCORE	
TIME	
Section 1 score	
Section 2 score	
TOTAL (42 points)	

Training Documents

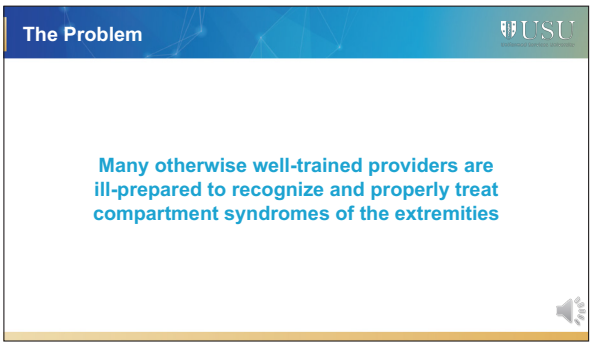
STUDENTS

WARNING:
The following content includes graphic images.

Instructions: Here is a preview of the slides in the PowerPoint Presentation. You are encouraged to take notes or ask questions as needed.



1



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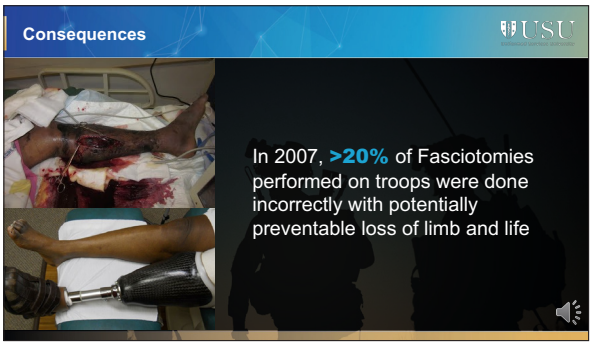


3

Loss of Limb or Life from CS

Thorough Understanding of Etiology and Diagnosis

Mastery of 2 incision 4 Compartment Fasciotomy

4

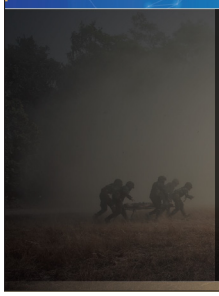
Etiology of Compartment Syndrome

There two general ways that CS develops:

1. Restriction of the size of the compartment
2. Increase in the volume of the compartment

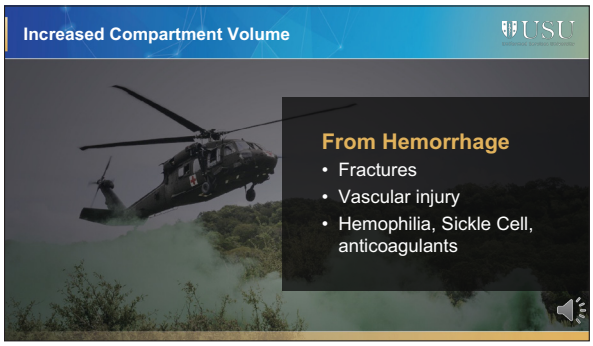
5

Restriction of the Size of the Compartment

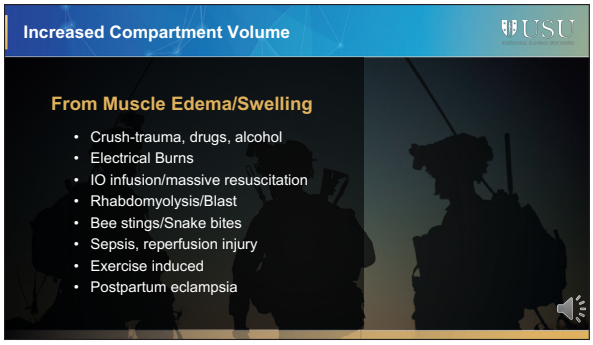


- Casts/splints
- Burn eschar
- Tourniquets
- Tight dressings
- Military antishock trousers
- Automated BP monitoring
- Malpositioning on OR table

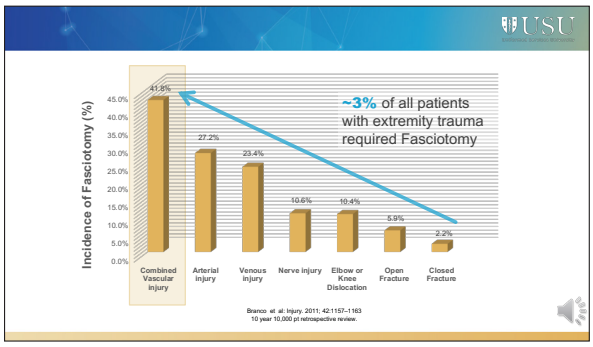
6


Increased Compartment Volume
From Hemorrhage
• Fractures
• Vascular injury
• Hemophilia, Sickle Cell, anticoagulants

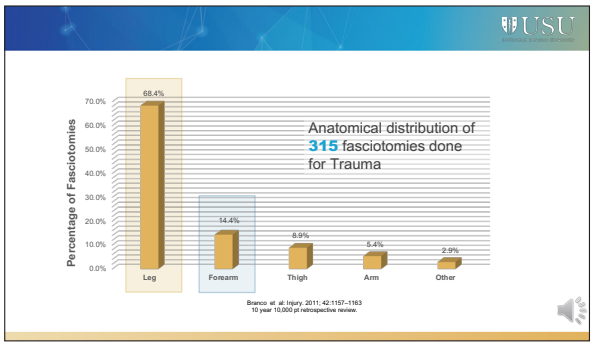
7


Increased Compartment Volume
From Muscle Edema/Swelling
• Crush-trauma, drugs, alcohol
• Electrical Burns
• IO infusion/massive resuscitation
• Rhabdomyolysis/Blast
• Bee stings/Snake bites
• Sepsis, reperfusion injury
• Exercise induced
• Postpartum eclampsia

8


Incidence of Fasciotomy (%)
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
41.8%
27.2%
23.4%
10.6%
10.4%
5.9%
2.2%
Combined Vascular Injury
Arterial injury
Venous injury
Nerve injury
Elbow or Knee Dislocation
Open Fracture
Closed Fracture
~3% of all patients with extremity trauma required Fasciotomy
Branco et al. Injury. 2011; 42:1157–1163
10 year 10,000 pt retrospective review.

9



10

Diagnosis

The diagnosis of CS requires **high index of suspicion** and recognition of subtle physical exam findings.

It is important to recognize and treat CS before irreversible cell damage occurs

11

Diagnosis - Classic Signs/Symptoms

The Five P's

- Pain
- Pallor
- Paresthesias
- Paralysis
- Pulselessness

The most important symptom of CS is pain greater than expected due to the injury alone.

12

Measurement of Compartment Pressures

- May be of value when exam is unreliable
- Commercial device or needle to arterial line transducer
- Pressure > 30 mm Hg or a Δp (diastolic BP – Comp. Press) < 30 is threshold for Dx of CS

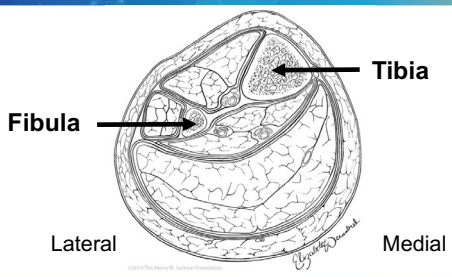
13

Fasciotomy of the Lower Leg

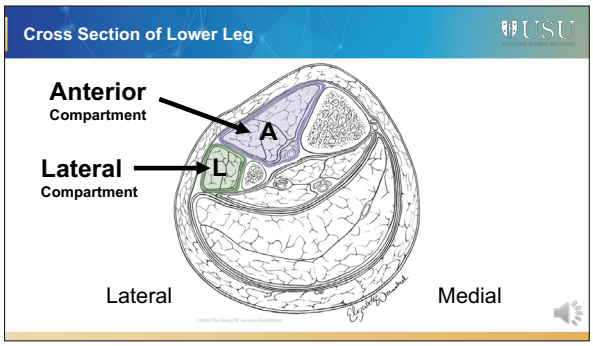
- The treatment of lower leg CS is prompt & proper Fasciotomy.
- Two Incision Four Compartment Fasciotomy is the standard in trauma.
- Must know the anatomy to do this correctly!

14

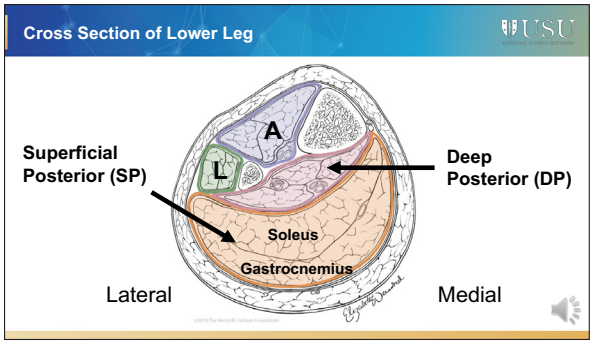
Cross Section of Lower Leg



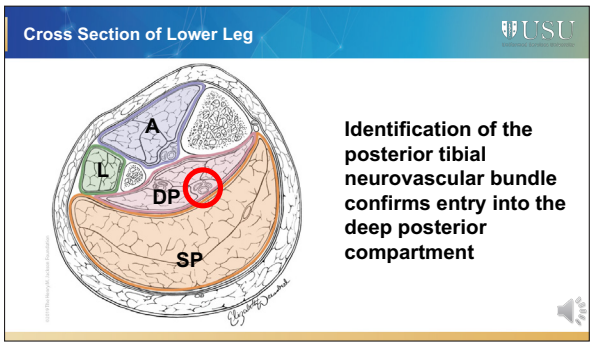
15


Cross Section of Lower Leg
Anterior
Compartment
Lateral
Compartment
A
L
Lateral
Medial

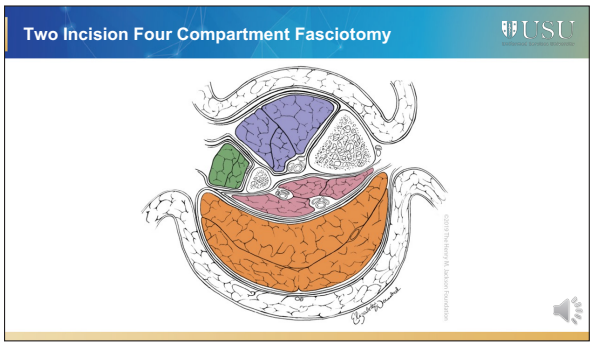
16


Cross Section of Lower Leg
Superficial
Posterior (SP)
Deep
Posterior (DP)
A
L
Soleus
Gastrocnemius
Lateral
Medial

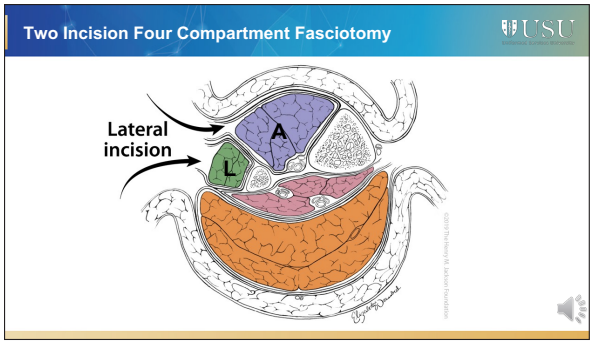
17


Cross Section of Lower Leg
A
L
DP
SP
Identification of the posterior tibial neurovascular bundle confirms entry into the deep posterior compartment

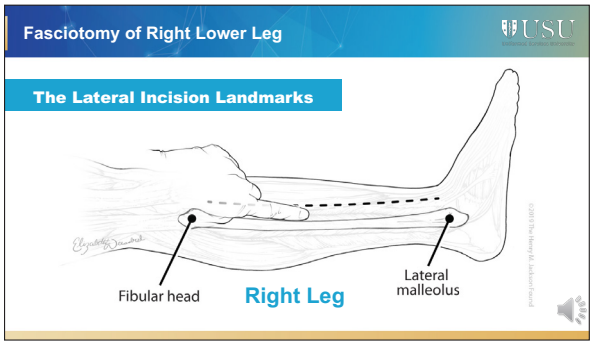
18


Two Incision Four Compartment Fasciotomy
USU

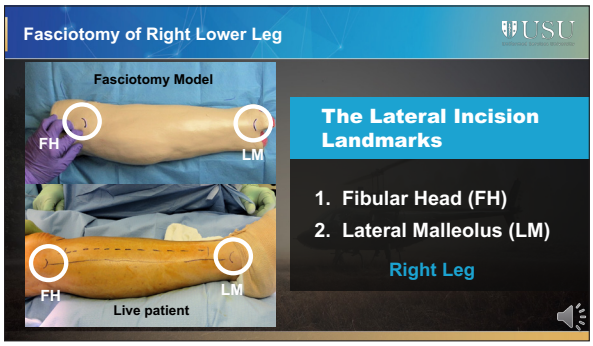
19


Two Incision Four Compartment Fasciotomy
USU
Lateral incision
A
L

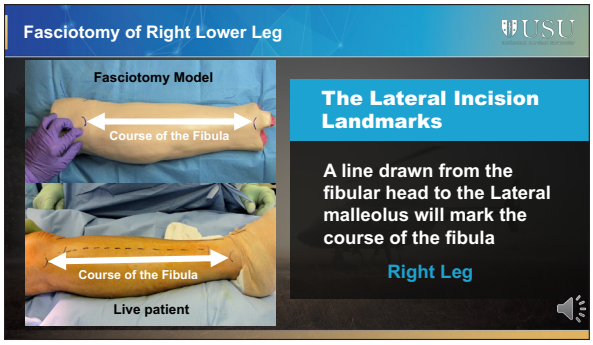
20


Fasciotomy of Right Lower Leg
USU
The Lateral Incision Landmarks
Fibular head
Right Leg
Lateral malleolus

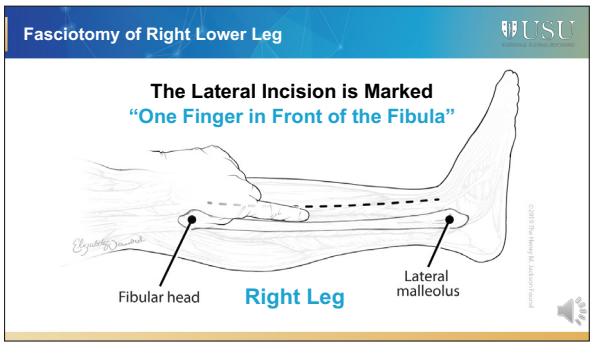
21


Fasciotomy of Right Lower Leg
Fasciotomy Model
FH
LM
FH
LM
Live patient
The Lateral Incision Landmarks
1. Fibular Head (FH)
2. Lateral Malleolus (LM)
Right Leg

22


Fasciotomy of Right Lower Leg
Fasciotomy Model
Course of the Fibula
Course of the Fibula
Live patient
The Lateral Incision Landmarks
A line drawn from the fibular head to the Lateral malleolus will mark the course of the fibula
Right Leg

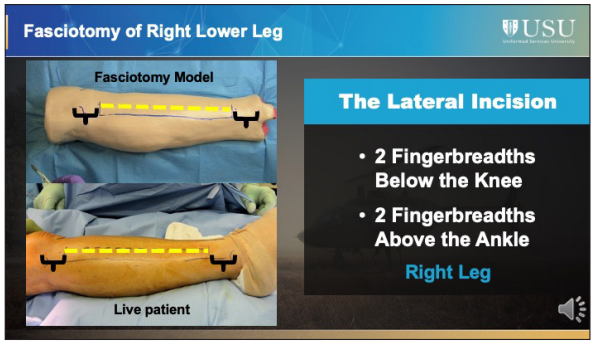
23


Fasciotomy of Right Lower Leg
The Lateral Incision is Marked
"One Finger in Front of the Fibula"
Fibular head
Lateral malleolus
Right Leg

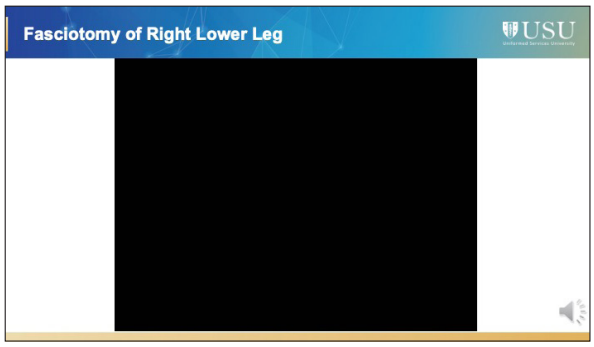
24


Fasciotomy of Right Lower Leg
USU
Fasciotomy Model
Live patient
The Lateral Incision Landmarks
"One Finger in Front of the Fibula"
Right Leg

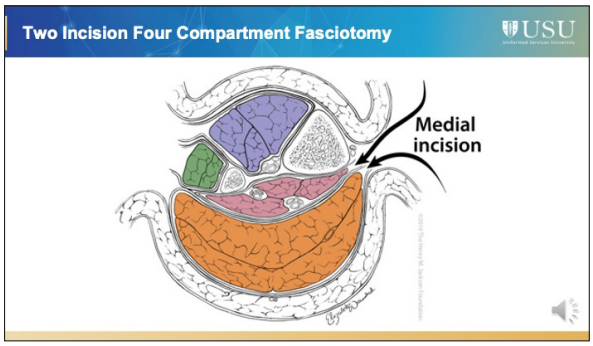
25


Fasciotomy of Right Lower Leg
USU
Fasciotomy Model
Live patient
The Lateral Incision
• 2 Fingerbreadths Below the Knee
• 2 Fingerbreadths Above the Ankle
Right Leg

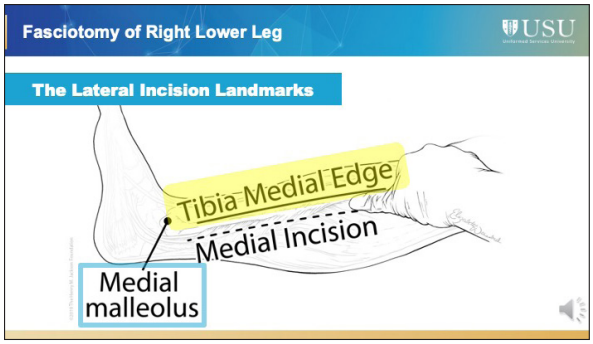
26


Fasciotomy of Right Lower Leg
USU

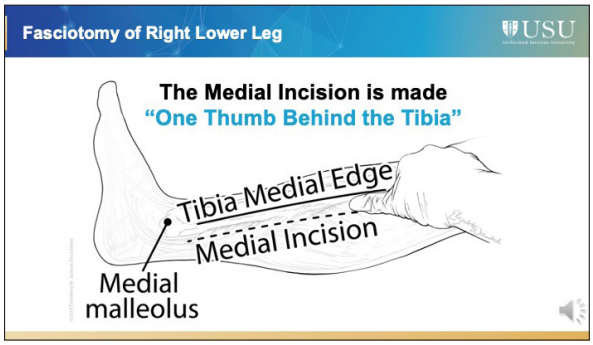
27


Two Incision Four Compartment Fasciotomy
USU
Medial incision

28


Fasciotomy of Right Lower Leg
USU
The Lateral Incision Landmarks
Tibia Medial Edge
Medial Incision
Medial malleolus

29


Fasciotomy of Right Lower Leg
USU
The Medial Incision is made
"One Thumb Behind the Tibia"
Tibia Medial Edge
Medial Incision
Medial malleolus

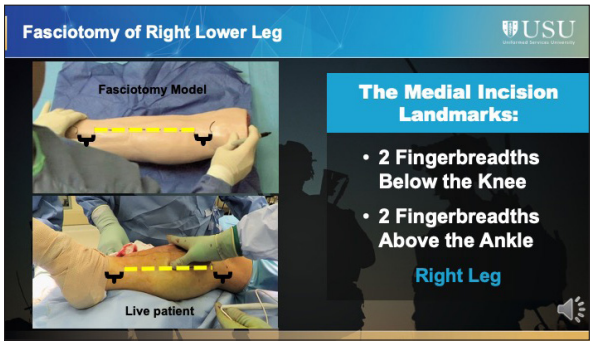
30


Fasciotomy of Right Lower Leg
USU
The Medial Incision
"One Thumb Behind the Tibia"
Right Leg

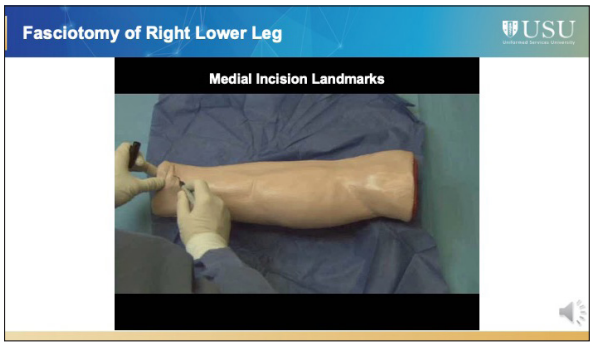
31


Fasciotomy of Right Lower Leg
USU
The Medial Incision
"One Thumb Behind the Tibia"
Right Leg

32


Fasciotomy of Right Lower Leg
USU
Fasciotomy Model
Live patient
The Medial Incision Landmarks:
• 2 Fingerbreadths Below the Knee
• 2 Fingerbreadths Above the Ankle
Right Leg

33


Fasciotomy of Right Lower Leg
USU
Medial Incision Landmarks

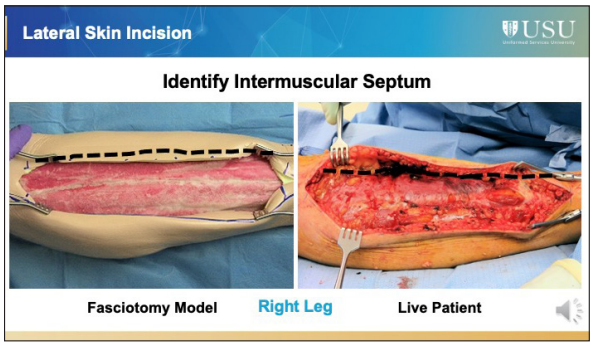
34


USU
LATERAL SKIN INCISION

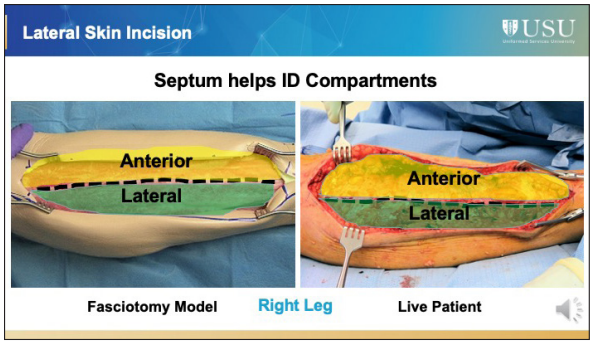
35


Lateral Skin Incision
USU
Fasciotomy Model
Right Leg
Live Patient

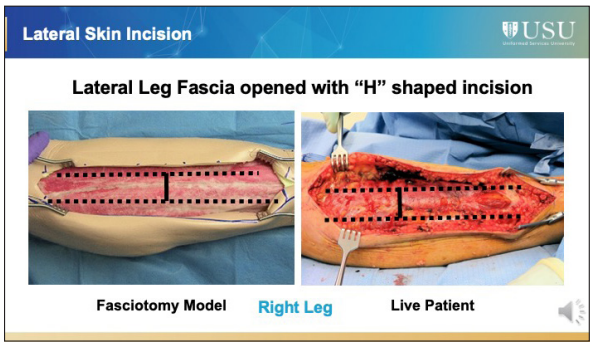
36


Lateral Skin Incision
USU
Identify Intermuscular Septum
Fasciotomy Model
Right Leg
Live Patient

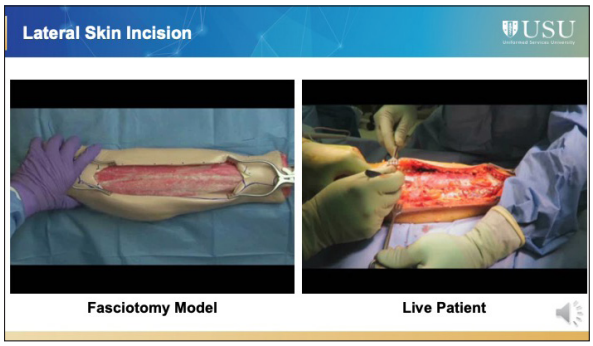
37


Lateral Skin Incision
USU
Septum helps ID Compartments
Anterior
Lateral
Anterior
Lateral
Fasciotomy Model
Right Leg
Live Patient

38


Lateral Skin Incision
USU
Lateral Leg Fascia opened with "H" shaped incision
Fasciotomy Model
Right Leg
Live Patient

39


Lateral Skin Incision
USU
Fasciotomy Model
Live Patient

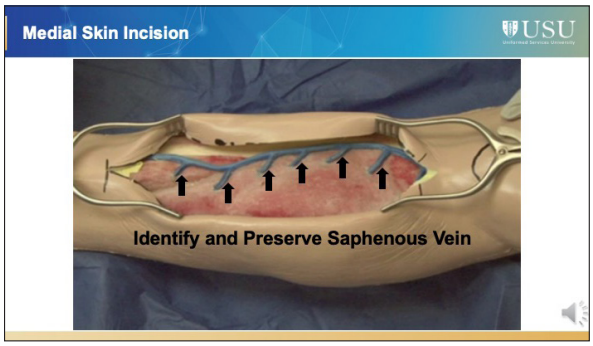
40


USU
MEDIAL SKIN INCISION

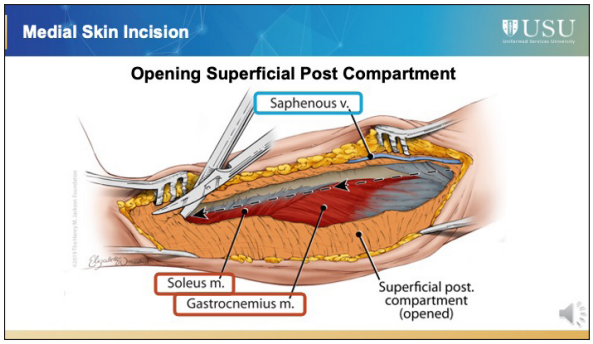
41


Medial Skin Incision
USU
Fasciotomy Model
Right Leg
Live Patient

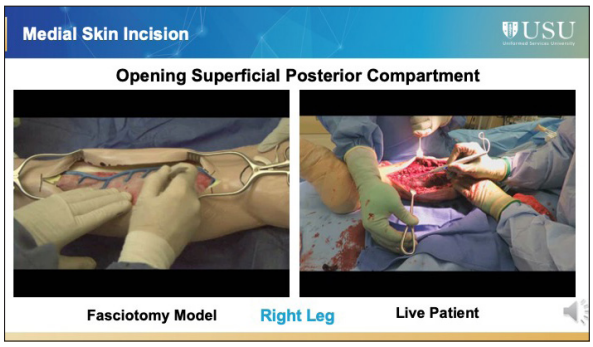
42


Medial Skin Incision
USU
Identify and Preserve Saphenous Vein

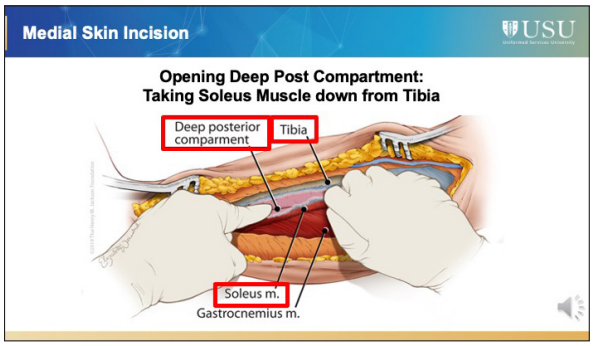
43


Medial Skin Incision
USU
Opening Superficial Post Compartment
Saphenous v.
Soleus m.
Gastrocnemius m.
Superficial post. compartment (opened)

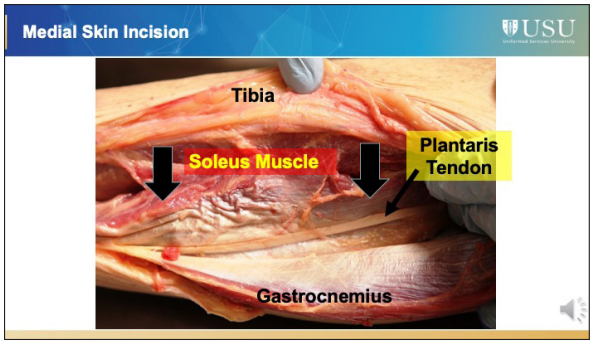
44


Medial Skin Incision
USU
Opening Superficial Posterior Compartment
Fasciotomy Model
Right Leg
Live Patient

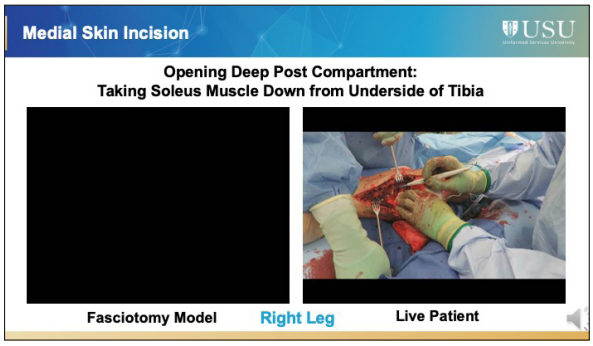
45


Medial Skin Incision
USU
Opening Deep Post Compartment:
Taking Soleus Muscle down from Tibia
Deep posterior comparment
Tibia
Soleus m.
Gastrocnemius m.

46


Medial Skin Incision
USU
Tibia
Soleus Muscle
Plantaris Tendon
Gastrocnemius

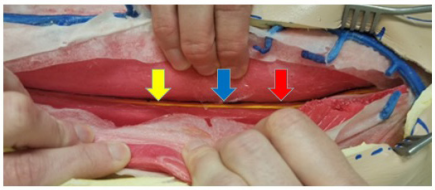
47


Medial Skin Incision
USU
Opening Deep Post Compartment:
Taking Soleus Muscle Down from Underside of Tibia
Fasciotomy Model
Right Leg
Live Patient

48

Medial Skin Incision

Identification of the Posterior Tibial Neurovascular Bundle Confirms Entry into Deep Posterior Compartment



Fasciotomy Model

49

Potential Pitfalls

- **Failure to identify the need for fasciotomy**
- **Failure to make adequate skin incisions**
  - Skin can act as a constricting bridge
- **Damage to underlying structures**
  - Superficial Peroneal nerve (Lateral Leg)
  - Saphenous Vein (Medial Leg)
- **Missing a compartment**
  - Anterior compartment most frequently missed
  - Deep Posterior compartment 2nd most frequently missed

50

Summary

- CS must be suspected in all polytrauma patients with extremity injury.
- All clinicians should have intimate knowledge of the etiology, diagnosis, and treatment.
- A High index of suspicion should be maintained
- Two Incision Four Compartment Fasciotomy is the standard in trauma, and understanding the anatomy is essential to performing this procedure correctly

51

Instructions: Assess your knowledge on Lateral Canthotomy and Cantholysis using this quiz.

Please circle the correct answer.

1. All of the following statements regarding the development of compartment syndrome (CS) of the extremities are true, except:
   a. Compartment syndrome can develop from muscle overuse.
   b. Patients with hypotension are less likely to develop CS due to decreased flow.
   c. Open fractures of the lower extremity are less likely to develop CS than closed fractures.
   d. Evenomation (snake bite) can lead to the development of CS.

2. The Pathophysiology of CS is related to all of the following mechanisms except?
   a. Reduction in the volume of the compartment – constrictive dressing.
   b. Impairment of the sodium channel pump in the nerve cell wall.
   c. Increase in the volume of the compartment.
   d. Reperfusion of the compartment after interruption of vascular flow.

3. Which of the following is the most sensitive early symptom or physical finding suggesting the diagnosis of lower extremity CS?
   a. Parathesias (numbness) of the foot.
   b. Loss of pulses in the lower extremities.
   c. Pain greater than expected due to the injury alone.
   d. Pallor of the lower extremity compared to the unaffected limb.

4. Which of the following injuries is most likely to be associated with a compartment syndrome?
   a. A dislocation of the knee.
   b. An open fracture of the tibia.
   c. A closed fracture of the tibia and fibula.
   d. A gunshot wound with injury to both the popliteal artery and vein.

5. In patients with an unreliable exam, measurement of compartment pressures may help to make the diagnosis of compartment syndrome. Which of the following measurements suggest that a compartment syndrome may be present?
   a. A delta pressure difference in pressure of less than 30 mm Hg.
   b. A compartment pressure greater than 20 mm Hg.
   c. A delta pressure difference in pressure of greater than 40 mm Hg.
   d. A compartment pressure less than 30 mm Hg.

6. The lateral aspect of the lower leg contains which of the following compartments?
   a. The superior and lateral compartments.
   b. The lateral and anterior compartments.
   c. The anterior and posterior compartments.
   d. The lateral and inferior compartments.

7. In the swollen extremity, the intramuscular septum on the lateral leg may be difficult to identify. Which of the following structures will best aid in the initial identification of the septum?
   a. The fibular head.
   b. The deep peroneal nerve.
   c. The perforating vessels.
   d. The lower edge of the tibia.

8. Compartment syndrome is most likely to occur in which decreasing order of frequency?
   a. Thigh > lower leg > upper arm> forearm.
   b. Thigh > upper arm > lower leg > forearm.
   c. Lower leg > thigh > forearm > upper arm.
   d. Lower leg >forearm > thigh > upper arm

9. The ideal placement of the medial incision when performing a two incision four compartment fasciotomy is?
   a. A “thumb” behind or below the palpable edge of the tibia.
   b. Directly over the course of the saphenous vein.
   c. Directly below the palpable edge of the tibia.
   d. Four finger breadths from the anterior tibial spine

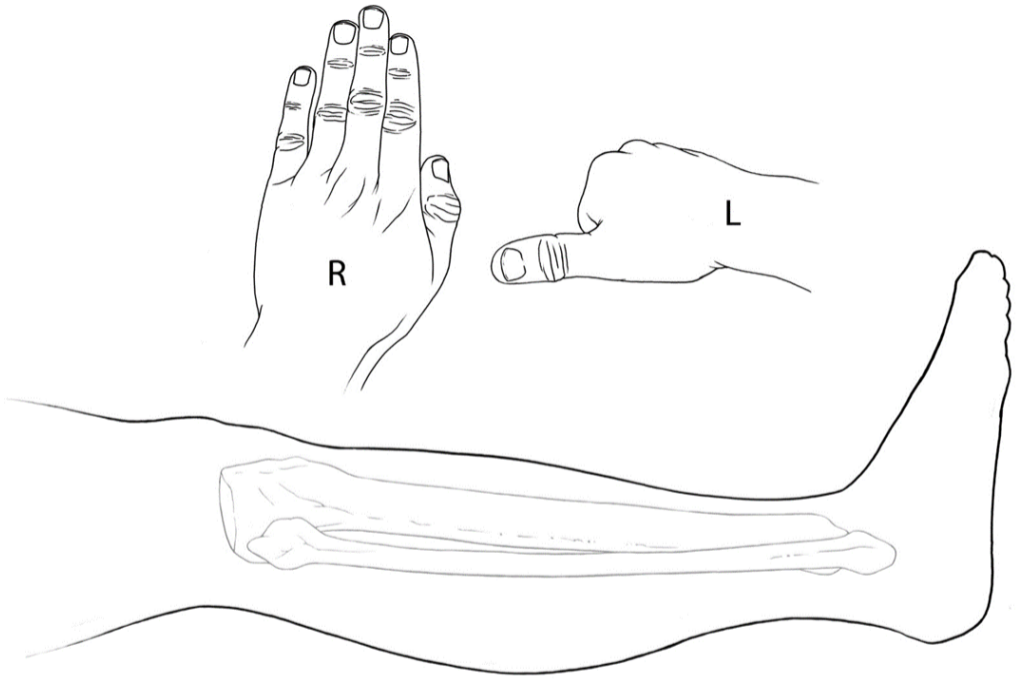
10. The compartment in the lower extremity that is most susceptible to developing CS?
    a. Lateral
    b. Superficial Posterior
    c. Medial
    d. Anterior
    e. Deep Posterior
    f. Inferior

11. Iatrogenic injury to the superficial peroneal nerve is most likely to occur when opening which compartment?
    a. Anterior
    b. Lateral
    c. Superficial Posterior.
    d. Deep Posterior
    e. Medial
    f. Superior

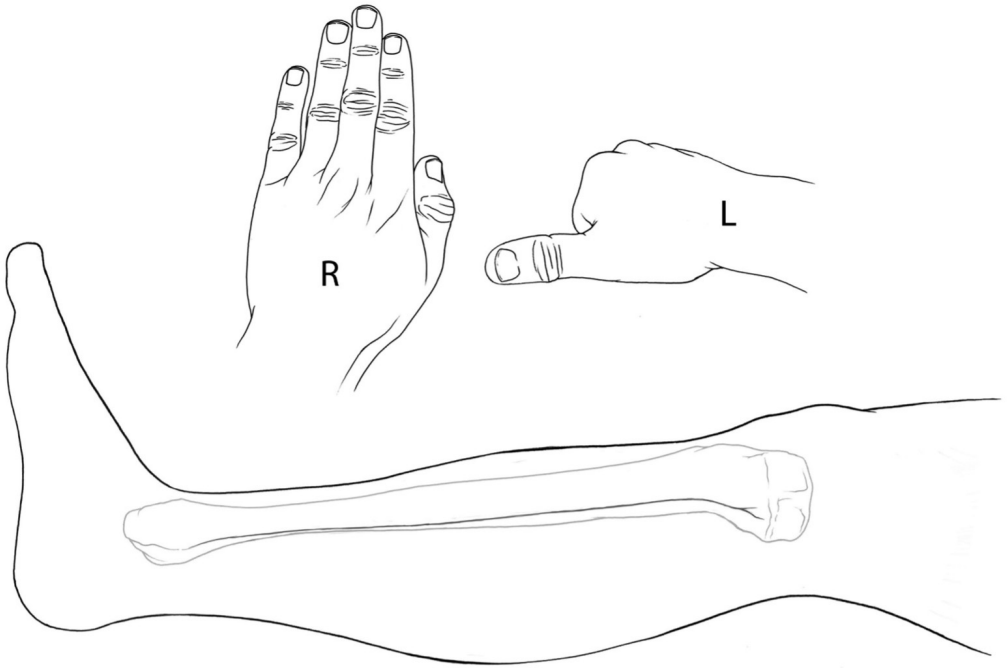
12. The posterior tibial artery is in which compartment?
    a. Superior
    b. Anterior
    c. Lateral
    d. Superficial Posterior
    e. Deep Posterior
    f. Medial

13. The soleus muscle is in which compartment?
    a. Deep Posterior
    b. Anterior
    c. Lateral
    d. Superficial Posterior
    e. Medial
    f. Superior

14. Please draw on the image below the ideal skin incision for performing the lateral incision of the lower leg for a fasciotomy. The hands and fingers are included to help judge relative scale?



15. Please draw on the image below the ideal skin incision for performing the medial incision of the lower leg for a fasciotomy.



Instructions: Use the practice procedural checklist below to guide you, step-by-step, on how to perform a fasciotomy. If critical steps are not completed correctly, re-attempt until proficiency is reached.

Execution Checklist

Lateral Skin Incision Marking		Skill Met
1	Marks head of fibula proximally	
2	Marks lateral malleolus at ankle	
3	Marks the course of the fibula	
4	Marks incision one finger in front of the fibula (1.5 - 2.5 cm)	
5	Marks upper end of incision 2-3 fingers (3.0 - 5.0 cm) below the knee	
6	Marks lower end of incision 2-3 fingers (3.0 - 5.0 cm) from the Lat. Malleolus (above ankle)	
	Lateral Skin Incision Marking Score (6):	

Medial Skin Incision Marking		Skill Met
1	Marks medial aspect of tibial plateau	
2	Marks medial malleolus	
3	Marks length of medial edge of tibia	
4	Marks incision line one thumb behind tibia	
5	Marks upper end of incision 2-3 fingers (3.0 - 5.0 cm) from Tibial Plateau (TP)	
6	Marks lower end of incision 2-3 fingers (3.0 - 5.0 cm) from the Med Malleolus	
	Medial Skin Incision Marking Score (6):	

Lateral Skin Incision		
1	Makes incision one finger in front of the fibula (1.5 - 2.5 cm)	
2	Upper end of incision is 2-3 fingers (3.0 - 5.0 cm) from inferior patella	
3	Lower end of incision is 2-3 fingers (3.0 - 5.0 cm) from the Lat. Malleolus	
	Lateral Skin Incision Score (3):	

Lateral Fasciotomy		Skill Met
1	Verbalizes/Identfies the correct location of the septum	
2	Make vertical portion of H shaped incision first across the septum	
3	Underruns fascia with closed scissors prior to opening fascia **(fully)**	
4	Opens fascia with partially closed scissor tips **(in a pushing method)**	
5	Points tips of scissors away from the septum **(in lateral compartment distally)**	
*6	**Opens fascia in anterior compartment ≥ 100% the length of the skin incision (3-5 cm from the inferior patella and 3-5 cm from the lat. Malleolus)**	
*7	**Opens fascia in lateral compartment ≥ 100% the length of the skin incision (3-5 cm from the inferior patella and 3-5 cm from the lat. Malleolus)**	
	Lateral Fasciotomy Score (7):	

Medial Skin Incision		Skill Met
1	Makes incision one finger in front of the fibula (1.5 - 2.5 cm)	
2	Upper end of incision is 2-3 fingers (3.0 - 5.0 cm) from inferior patella	
3	Lower end of incision is 2-3 fingers (3.0 - 5.0 cm) from the Lat. Malleolus	
	Medial Skin Incisiion Score (3):	

Medial Fasciotomy		Skill Met
1	Verbally identifies and does not injure greater saphenous vein	
*2	**Opens fascia over the superficial compartment ≥ 100% the length of the skin incision (3-5 cm from the tibial plateau and 3-5 cm from the med. Malleolus)**	
3	Takes down the soleus bridge from the tibia to expose the deep posterior compartment	
*4	**Opens the fascia over the deep posterior compartment ≥ 100% the length of the skin incision (3-5 cm from the tibial plateau and 3-5 cm from the med. Malleolus)**	
5	Demonstrates the posterior tibial neurovascular bundle is visible in the deep compartment	
	Medial Fasciotomy Score (5):	
Total Time of procedure:	Time of procedure from first incision to subject verbalizes DONE	_____:_____ (min) (sec)
Total Fasciotomy Score (x/30):	Total all scores from each sub section	
Procedure Execution Complete		

BOOKLET PRINTING INSTRUCTIONS

The Damage Control Procedures booklet is included with your student materials.

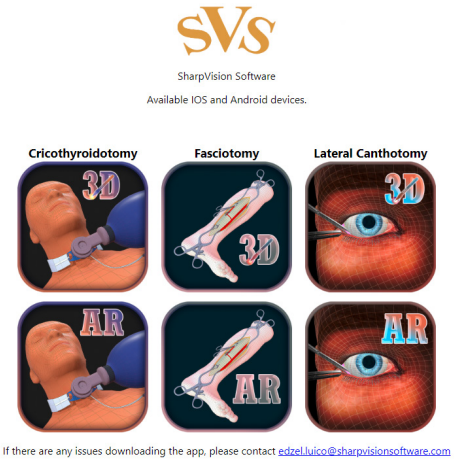
1. Print this booklet out, preferably on cardstock
2. Staple or hole punch pages to bind
3. Keep booklet easily accessible for quick reference if needed

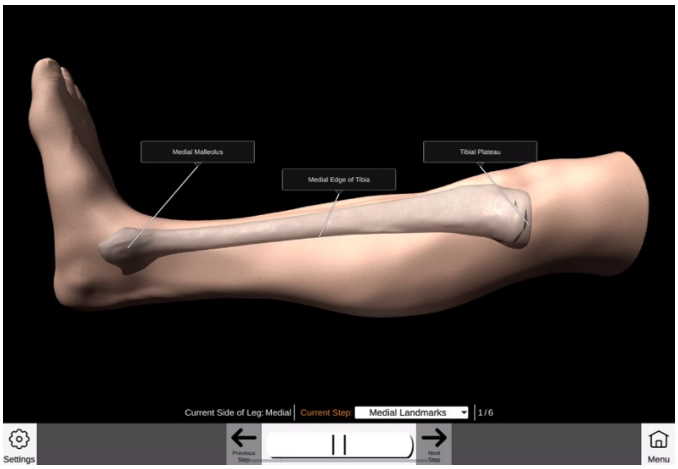
The **Virtual Reality Fasciotomy Application** (For both Android/Apple) is available here:

iOS: **http://battlefieldarassist.us/**
Android: **https://drive.google.com/drive/folders/1dlW-91rve8iKvMKYuSZjhBB4t1MJ298O**.

Encourage students to download the app after the training. The app can be accessed at any time to refresh their memory on knowledge and procedural practice.

This application can be used to view a Cricothyroidotomy demonstration, as well as testing knowledge and skills.





References & Award Information

Study References

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4. Hope MJ, McQueen MM. Acute compartment syndrome in the absence of fracture. J Orthop Trauma. 2004;18:220-224.

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6. Williams AB, Luchette FA, Papconstantinou HT. The effects of early vs. late fasciotomy in the management of extremity trauma. Surgery. 1997;122:861-866.

7. Finkelstein JA, Hunter GA, Hu RW. Lower limb compartment syndrome: course after delayed fasciotomy. J Trauma 1996; 40:342-344. Guerrero A, Gibson K, Kralovich KA, et al. Limb los

Award Information

a. “The Uniformed Services University of the Health Sciences (USU Award Number HU00012120018), 4301 Jones Bridge Rd., A1040C, Bethesda, MD 20814-4799 is the awarding and administering office;” and:

b. “This project is (or was) sponsored by the Uniformed Services University of the Health Sciences (USU); however, the information or content and conclusions do not necessarily represent the official position or policy of, nor should any official endorsement be inferred on the part of, USU, the Department of Defense, the Henry M. Jackson Foundation for the Advancement of Military Medicine Inc, or the U.S. Government.

Author Affiliation

1. Henry M. Jackson Foundation for the Advancement of Military Medicine, Inc. 2. Uniformed Services University of the Health Sciences. 3. Womack Army Medical Center

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The Henry M Jackson Foundation for the Advancement of Military Medicine, Inc.

Uniformed Services University

4301 Jones Bridge Road
Bethesda, MD 20814
usuhs.edu