

CURRICULUM

A Formalized Three-Year Emergency Medicine Residency Musculoskeletal Emergencies Curriculum

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ABSTRACT:

Audience and type of curriculum: The Ohio State University Emergency Medicine Residency Program Musculoskeletal Emergencies Curriculum is a three-year curriculum for PGY-1 to PGY-3 learners.

Introduction/Background: Musculoskeletal complaints/injuries compose a significant proportion of emergency department visits; in fact, many can result in significant morbidity. These conditions present in a vast array of acuities from minor to life/limb threatening. Emergency medicine physicians must be facile in diagnosing and managing various musculoskeletal conditions. We aim to present a three-year curriculum that incorporates clinical experience, self-directed learning, and small group-based didactics using the flipped classroom model to allow learners to master the diagnosis and management of musculoskeletal emergencies. This curriculum will provide progressive training in the diagnosis and management of musculoskeletal emergencies.

Objectives: Resident learners will master the diagnosis and management of emergent musculoskeletal conditions including fractures/dislocations, soft tissue injuries, compartment syndrome, joint complaints, infections, and complex injuries.

Methods: The educational strategies used in this curriculum include: independent, self-directed learning via textbook and medical literature reading, didactic sessions describing the diagnosis and management of musculoskeletal conditions, a four-week orthopedic surgery rotation, and an optional four-week rotation at a medical center-affiliated sports medicine practice. Residents are expected to actively participate in the care of patients with musculoskeletal conditions/injuries presenting to the emergency department during the course of their residency training. The time requirements, reading material, and diagnosis/management techniques taught vary depending on the year of training.



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Length of curriculum: The entirety of the curriculum is three years; however, each year of residency training has specific objectives and educational material.

Topics: Curriculum, medical education, sports medicine, musculoskeletal injury.



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Learner Audience:

Interns, Junior Residents, Senior Residents

Length of Curriculum:

3 years

Topics:

Curriculum, Medical Education, Sports Medicine, Musculoskeletal Injury.

Brief introduction:

Musculoskeletal complaints and injuries comprise a significant proportion of emergency department visits, and many can result in significant morbidity.¹ Presentations can vary widely in acuity ranging from minor to life/limb threatening; therefore, emergency physicians must be facile in the diagnosis and management of such conditions. This formalized curriculum presents the diagnosis and management of musculoskeletal emergencies in a novel manner using clinical experience, minimal lecture content, self-directed learning, and small group discussions.

Our curriculum will address diagnosis and management of the following musculoskeletal conditions, which are considered core content as outlined in the 2013 ABEM Emergency Medicine Model of Clinical Practice²:

Bony Abnormalities

- Aseptic/Avascular necrosis
- Osteomyelitis
- Tumors

Disorders of the Spine

- Disc disorders
- Inflammatory spondylopathies

- Low back pain
- Cauda equina syndrome
- Sacroiliitis
- Sprains/Strains

Joint Abnormalities

- Arthritis
 - Septic
 - Crystal arthropathies
 - Rheumatoid
 - Juvenile
 - Osteoarthritis
- Congenital dislocation of the hip
- Slipped capital femoral epiphysis

Muscle Abnormalities

- Myositis
- Rhabdomyolysis

Overuse Syndromes

- Bursitis
- Muscle strains
- Peripheral nerve syndrome
- Carpal tunnel syndrome
- Tendonitis

Soft Tissue Infections

- Fasciitis
- Felon
- Gangrene
- Paronychia
- Synovitis/Tenosynovitis

Trauma

- Injuries of the spine
 - Dislocations/Subluxations
 - Fractures
 - Sprains/Strains
- Extremity bony trauma
 - Dislocations/Subluxations
 - Fractures (open and closed)
- Pediatric fractures
 - Epiphyseal
 - Salter-Harris classification
 - Greenstick
 - Torus
- Pelvic fracture
- Soft-tissue extremity injuries
 - Amputations/Replantation
 - Compartment syndromes
 - High-pressure injection
 - Injuries to joints
 - Penetrating trauma
 - Periarticular
 - Sprains/Strains
 - Tendon injuries
 - Lacerations/Transections

Trauma con't



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- Ruptures
 - Achilles tendon
 - Patellar tendon
- Spinal cord and nervous system trauma
 - Cauda equina syndrome
 - Injury to nerve roots
 - Peripheral nerve injury
 - Spinal cord injury
- Spinal cord injury without radiologic abnormality (SCIWORA)

Problem identification, general and targeted needs assessment:

Musculoskeletal complaints are among the most common reasons patients visit physicians and represent up to 20% of visits to the emergency department (ED).³ Despite this, Comer et al. demonstrated lack of proficiency in musculoskeletal medicine in emergency physicians, with only 61% of physicians surveyed passing a validated examination of musculoskeletal knowledge.⁴ Furthermore, at both the undergraduate and graduate medical education levels, competency in musculoskeletal medicine is widely considered to be a deficiency in medical training in the United States.⁵⁻⁶ For example, at our institution, many patients presenting with musculoskeletal complaints are triaged to the zone of our emergency department staffed solely by an advanced practice provider. This limits resident learner exposure to some musculoskeletal pathology. Clearly, a formalized curriculum in musculoskeletal medicine tailored to emergency physicians' needs should be introduced to address these deficiencies.

At this time, the 2013 Model of Emergency Medicine Clinical Practice provides guidelines for best practices in delivering musculoskeletal education to EM residents. Some programs include an orthopedic rotation designed specifically for EM residents to familiarize them with the most commonly encountered orthopedic injuries presenting to the ED. Positive post-rotation surveys and Likert scores indicating increased comfort with core content areas have suggested this practice may be a useful educational model.⁷ Others have incorporated novel sports medicine curricula consisting of didactics, reading materials, and rotating through sports medicine clinics that compared favorably with their institution's standard orthopedic rotation.⁸ We plan to incorporate many of these elements into our curriculum, including targeted didactics, small group discussions, fracture conferences, independent learning, and orthopedic and sports medicine rotations.

Musculoskeletal injuries are clearly important parts of emergency medicine. While a formalized curriculum should be introduced, there are currently no "best practices" guidelines for implementation. Our proposed curriculum provides a comprehensive longitudinal education model for resident

learners over a 36-month residency program. While this is a proposed three-year curriculum, it could be easily adapted to a four-year training program based on their specific needs. Our didactic curriculum repeats every 18 months; therefore, each resident should experience the material twice during the course of their residency training. The didactic sessions are designed to be flexible based on residency program needs. The curricular content can be completed consecutively in a module format, or it can be evenly spaced throughout the entire didactic schedule. In an effort to preserve the educational value of the small group discussions for every level of learner, we recommend that each learner level focus on a specific topic to contribute to the discussion. Within the small group, PGY-1 residents discuss the pathophysiology, PGY-2 residents discuss the diagnosis and management, and PGY-3 residents focus on clinical controversies associated with the musculoskeletal conditions covered.

Goals of the curriculum:

Learning objectives for each year of training will vary, but the curriculum is designed with the overall goal of providing resident learners with the knowledge, experience, and skills to master the diagnosis and management of the myriad of musculoskeletal conditions including fractures/dislocations, compartment syndrome, joint complaints, infections, and complex injuries. The following objectives will be longitudinal, with specific objectives for each year of residency listed after.

1. Develop a deeper working knowledge of the diagnosis and management of various musculoskeletal conditions (MK, PROF, PC, PBLI, SBP, ICS).
2. Develop advanced physical examination skills for the assessment of the patient presenting to the emergency department with a musculoskeletal injury (MK, PROF, PC, PBLI, SBP, ICS).
3. Develop and improve emergency musculoskeletal procedural skills (MK, PROF, PC, PBLI, SBP, ICS).
4. Gain increased knowledge and exposure to sports medicine and the care of various musculoskeletal conditions encountered in the emergency department (MK, PROF, PC, PBLI, SBP, ICS).

Objectives of the curriculum:

There are five components to the curriculum: didactics, independent learning, small group discussions, an orthopedic surgery rotation, and an optional sports medicine rotation. Specific learning objectives for PGY-1 through PGY-3 are described below and will be achieved through the learning modalities described in the curriculum chart.

PGY-1 Learning Objectives



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After the successful completion of their PGY-1 year, residents will be able to competently:

1. Identify fractures and bony abnormalities on X-ray.
2. Obtain appropriate history and physical exam for musculoskeletal complaints.
3. Distinguish between acute vs chronic musculoskeletal complaints.
4. Appropriately disposition musculoskeletal complaints.
5. Develop musculoskeletal procedural skills.

PGY-2 Learning Objectives

After the successful completion of their PGY-2 year, residents will be able to competently:

1. Proficiently perform the appropriate history, physical exam, and disposition for musculoskeletal complaints in the ED.
2. Perform musculoskeletal procedures including arthrocentesis, splinting, and fracture reduction/management, under supervision.
3. Manage core content musculoskeletal complaints in the ED, with assistance.

PGY-3 Learning Objectives

After the successful completion of their PGY-3 year, residents will be able to competently:

1. Manage musculoskeletal complaints independent of orthopedic consultants, akin to a community emergency physician.
2. Demonstrate advanced understanding of musculoskeletal complaint disposition, including determining appropriateness of consults to orthopedics in both the academic and community setting.
3. Adapt training to one's future independent practice as an emergency physician.
4. Teach junior residents and articulate "pearls" of musculoskeletal medicine.

Goals of the sports medicine rotation, which residents may elect to complete starting in their PGY-1 year, are provided below.

Goals of the Sports Medicine Rotation

1. Residents will complete a 4-week sports medicine block rotation under the supervision of EM-trained sports medicine faculty and orthopedic faculty.
2. Residents will develop deeper understanding for the diagnosis and management of complaints considered to be core content for sports and musculoskeletal medicine, as listed previously.
3. Residents will develop advanced physical exam skills appropriate for assessing musculoskeletal injury.

4. Residents will develop and enhance procedural skills necessary to musculoskeletal medicine, including but not limited to arthrocentesis and joint reduction under sedation.
5. Residents will gain proficiency in the independent management of complaints considered to be core content of musculoskeletal and sports medicine.
6. Once proficiency in core content has been established, residents will meet with sports medicine faculty to identify deficiencies and develop a personalized curriculum with individualized learning goals.
7. Residents will complete a self-assessment identifying skills needing further development with sports medicine faculty and will review goals and update as appropriate.

Educational Strategies:

(See curriculum chart) Please see the separate document of linked objectives and educational strategies.

Evaluation and Feedback: This formalized musculoskeletal emergencies curriculum was specifically designed to address and incorporate feedback, compiled over the past several years, from both resident learners and faculty members. Our curricular model will remain dynamic through the utilization of evaluations and feedback obtained. The curriculum will be critically evaluated and updated by education and sports medicine faculty members in order to ensure the educational material remains current and consistent with best practices.

Outcome measures to ensure that curricular goals and objectives are met include: clinical evaluations, direct observation, procedural assessments to ensure mastery, and participation assessment in small group discussions.

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Additional Resources: A complete list of resources and educational materials is listed below.

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Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, resources Needed (Space, Instructors, Equipment, citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
Joint Complaints	<p>-“Flipped” Classroom Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p> <p>-Patient Care</p> <p>-60-120 minute Arthrocentesis Procedure Lab</p>	<p>-Pathophysiology, Diagnosis, and Management of Joint Complaints</p> <p>-Kocher Criteria for Septic Joint in Children</p> <p>-Distinguishing Factors Between Septic Joint and Transient Synovitis</p>	<p>By the end of this session, learners will:</p> <p>Review pathophysiology, diagnosis and treatment of pediatric and adult joint complaints.</p> <p>Review the application of various clinical decision rules applicable to knee pain</p> <p>Discuss questions posed by residents in their pre-work assignments.</p> <p>Summarize key learning points</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable. Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Education Faculty Members or Content Experts. Pre-Determined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p> <p>Needles, Syringes, Joint Models for Demonstration and Practice of Arthrocentesis of Various Joints</p>	<p>Milestone: PC 1-11, 13-14, MK, PROF 1-2, ICS 1-2, PBLI, SBP1-2</p> <p>Assessment: --- Learner Preparation and Participation -Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



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Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, resources Needed (Space, Instructors, Equipment, citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
Non-Infectious Musculoskeletal Causes of Pain	<p>-“Flipped” Classroom Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p> <p>-Patient Care</p>	<p>-Pathophysiology, Diagnosis, and Management of Non-Traumatic Causes of Musculoskeletal Pain</p> <p>-Pathophysiology, Diagnosis, and Management of Compartment Syndrome</p> <p>-Discuss the Role of Bicarbonate in the Treatment of Rhabdomyolysis</p> <p>-Review the Various Risk Factors and Presentations for Rhabdomyolysis</p>	<p>By the end of this session, learners will:</p> <p>Review pathophysiology, diagnosis and treatment of non-traumatic causes of musculoskeletal pain, compartment syndrome, and rhabdomyolysis.</p> <p>Review the lab abnormalities associated with rhabdomyolysis</p> <p>Discuss questions posed by residents in their pre-work assignments.</p> <p>Summarize key learning points</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable. Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Education Faculty Members or Content Experts. Pre-Determined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p>	<p>Milestone: PC 1-11, 13-14, MK, PROF 1-2, ICS 1-2, PBLI, SBP1-2</p> <p>Assessment: --- Learner Preparation and Participation -Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>
Soft Tissue Infections	<p>-“Flipped” Classroom Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p> <p>-Patient Care</p>	<p>-Pathophysiology, Diagnosis, and Management of Musculoskeletal Soft Tissue Infections</p> <p>-Differential Diagnosis of a Red, Warm Extremity</p> <p>-Exam Findings for Flexor Tenosynovitis</p> <p>-Diagnosis and Management of Septic Joints</p>	<p>By the end of this session, learners will:</p> <p>-Review the pathophysiology, diagnosis, and treatment of musculoskeletal soft tissue infections</p> <p>-Critically discuss the differential diagnosis of erythematous, inflamed extremities</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable. Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Education Faculty Members or Content Experts. Pre-Determined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p>	<p>Milestone: PC 1-11, 13-14, MK, PROF 1-2, ICS 1-2, PBLI, SBP1-2</p> <p>Assessment: --- Learner Preparation and Participation -Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



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Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, resources Needed (Space, Instructors, Equipment, citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
Necrotizing Infections	<p>-“Flipped” Classroom Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p> <p>-Patient Care</p>	<p>-Pathophysiology, Diagnosis, and Management of Necrotizing Infections</p> <p>-Presentations of Necrotizing Fasciitis, Fournier’s Gangrene, and Clostridial Myonecrosis</p> <p>-Emphasis on Surgery as Mainstay of Treatment</p> <p>-HBO in Management of These Conditions</p> <p>-Preferred Imaging Modalities Based on Presentation</p>	<p>By the end of this session, learners will:</p> <p>-Review pathophysiology, diagnosis and treatment of necrotizing skin infections.</p> <p>-Review the different presentations of necrotizing fasciitis, Fournier’s Gangrene, and clostridial myonecrosis.</p> <p>-Discuss questions posed by residents in their pre-work assignments.</p> <p>-Discuss the management of these conditions and the role for HBO</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable. Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Education Faculty Members or Content Experts. Pre-Determined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p>	<p>Milestone: PC 1-11, 13-14, MK, PROF 1-2, ICS 1-2, PBLI, SBP1-2</p> <p>Assessment: --- Learner Preparation and Participation -Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



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Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, resources Needed (Space, Instructors, Equipment, citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
Lower Extremity Injuries	<p>-“Flipped” Classroom Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p> <p>-Patient Care</p> <p>-60-120 Minute Casting and Splinting Workshop</p>	<p>-Pathophysiology, Diagnosis, and Management of Pediatric Lower Extremity Orthopedic Injuries</p> <p>-Pathophysiology, Diagnosis, and Management of Adult Lower Extremity Orthopedic Injuries</p> <p>-Compartment Syndrome</p> <p>-Identification and Differences in Management of Toddler Fractures and Non-Accidental Trauma</p>	<p>By the end of this session, learners will:</p> <p>-Review pathophysiology, diagnosis and treatment of pediatric and adult lower extremity orthopedic injuries.</p> <p>-Review pathophysiology, diagnosis and treatment of compartment syndrome.</p> <p>-Discuss questions posed by residents in their pre-work assignments.</p> <p>-Discuss clinical decision rules for obtaining imaging in patients with ankle or knee pain.</p> <p>-Summarize key learning points</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable. Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Education Faculty Members or Content Experts. Pre-Determined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p> <p>Splinting and Casting Supplies for the Splinting Workshop. Learners Will Practice on Each Other</p>	<p>Milestone: PC 1-11, 13-14, MK, PROF 1-2, ICS 1-2, PBLI, SBP1-2</p> <p>Assessment: --- Learner Preparation and Participation -Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



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Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, resources Needed (Space, Instructors, Equipment, citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
Upper Extremity Injuries	<p>-“Flipped” Classroom Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p> <p>-Patient Care</p> <p>-60-120 Minute Casting and Splinting Workshop</p>	<p>-Pathophysiology, Diagnosis, and Management of Pediatric Upper Extremity Orthopedic Injuries</p> <p>-Pathophysiology, Diagnosis, and Management of Adult Upper Extremity Injuries</p> <p>-Salter-Harris Classification of Pediatric Fractures</p> <p>-Management of Specific Orthopedic Injuries and How Management May Differ in Community Practice</p> <p>-Physical Examination of the Hand</p>	<p>By the end of this session, learners will:</p> <p>-Review pathophysiology, diagnosis and treatment of pediatric and adult upper extremity orthopedic injuries.</p> <p>-Discuss questions posed by residents in their pre-work assignments.</p> <p>-Summarize key learning points</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable. Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Education Faculty Members or Content Experts. Pre-Determined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p> <p>Splinting and Casting Supplies for the Splinting Workshop. Learners Will Practice on Each Other</p>	<p>Milestone: PC 1-11, 13-14, MK, PROF 1-2, ICS 1-2, PBLI, SBP1-2</p> <p>Assessment: --- Learner Preparation and Participation -Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



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Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, resources Needed (Space, Instructors, Equipment, citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
Diagnostic Approach to Low Back Pain	<p>-“Flipped” Classroom Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p> <p>-Patient Care</p>	<p>-Review the pathophysiology, differential diagnosis, and diagnostic modalities and indications for the presentation of back pain</p> <p>-Clinical decision rules for cervical spine clearance</p> <p>-EBM based plan for pain management</p> <p>-Imaging modalities and associated indications</p> <p>-Discuss questions posed by residents in their reading assignments</p> <p>-Summarize key learning points</p>	<p>By the end of this session, learners will:</p> <p>-Review the pathophysiology, differential diagnosis, and diagnostic modalities and indications for the presentation of back pain</p> <p>-Utilize EBM to develop an algorithm for risk stratifying patients presenting with low back pain</p> <p>-Discuss the physical examination for bac pain focusing on the tests that can identify nerve root compression</p> <p>-Develop an EBM based plan for pain control</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable. Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Education Faculty Members or Content Experts. Pre-Determined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p>	<p>Milestone: PC 1-11, 13-14, MK, PROF 1-2, ICS 1-2, PBLI, SBP1-2</p> <p>Assessment: --- Learner Preparation and Participation -Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



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Topic	Recommended Educational Strategy	Educational Content	Objectives	Learners	Timing, resources Needed (Space, Instructors, Equipment, citations of JETem pubs or other literature)	Recommended Assessment, Milestones Addressed
High Risk Back Pain	<p>-“Flipped” Classroom Discussion of Pre-reading Material, Case Discussions, and Discussion Questions</p> <p>-Encourage Participants to Share Clinical Experiences to Enhance Discussion</p> <p>-15 Minutes for Brief Topic Review and 30-45 Minutes for Case and Content Discussion</p> <p>-Patient Care</p>	<p>-Review the pathophysiology, differential diagnosis, and diagnostic modalities for high risk causes of back pain</p> <p>-Epidural Abscess and Cauda Equina Syndrome</p> <p>-Use of steroids in the treatment of sciatica</p>	<p>By the end of this session, learners will:</p> <p>-Review the pathophysiology, differential diagnosis, and diagnostic modalities for high risk causes of back pain</p> <p>-Discuss the diagnoses of cauda equine syndrome and epidural abscess</p> <p>-Discuss questions posed by residents in their reading assignments</p> <p>-Summarize key learning points</p>	PGY-1 PGY-2 PGY-3 Medical Students Faculty	<p>Equipment: Projector and Screen Preferable. Tables and Space Promoting Small Group Discussion.</p> <p>Instructors: 2 Education Faculty Members or Content Experts. Pre-Determined Senior Resident Discussion Leader</p> <p>Timing: Small Group Discussions Involve No More than 15 Learners and Last 45-60 Minutes</p>	<p>Milestone: PC 1-11, 13-14, MK, PROF 1-2, ICS 1-2, PBLI, SBP1-2</p> <p>Assessment: --- Learner Preparation and Participation -Senior Resident Teaching Skills</p> <p>Evaluation: Post-test created using a purchased question bank</p>



Appendix A: Joint Complaints

Author: Jennifer Mitzman, MD

Objectives

1. Review the differential diagnosis of non-traumatic pediatric hip pain.
2. Discuss the utility of the different aspects of the Kocher Criteria including fever, elevated inflammatory markers, refusal to bear weight, and elevated white blood cell (WBC) counts.
3. Describe useful diagnostic tests in non-traumatic or traumatic pediatric and adult hip pain.
4. Discuss imaging modalities which are indicated for various types of knee injuries encountered in the ED.
5. Review clinical decision rules for evaluating traumatic knee pain – contrasting the Ottawa and Pittsburgh criteria.
6. Discuss the management of common traumatic knee injuries – tibial plateau fracture, knee dislocations, and patellar dislocations

Case Studies:

Case 1: A 7-year-old girl is brought to the emergency department by her father, who states that she started complaining of left leg pain last night, and upon awakening this morning, refused to bear weight on her left leg. She has a fever to 102°F. No associated upper respiratory infection (URI) or gastrointestinal (GI) complaints. Father and patient deny any known trauma. She cries with any manipulation of the leg.

Question Prompts:

1. List the potential sources for this child's complaints and describe their pathophysiology.
 - a. Hip pathology is most likely. Consider septic arthritis, transient (toxic) synovitis, non-accidental trauma, slipped capital femoral epiphysis (SCFE), fracture/dislocation, avascular necrosis, osteomyelitis
 - b. Knee pathology such as septic joint must also be considered
2. What is the most appropriate diagnostic evaluation for this child?
 - a. Utilize Kocher Criteria help differentiate between septic arthritis and transient synovitis. Kocher Criteria consists of fever, refusal to bear weight, elevated erythrocyte sedimentation rate (ESR), and elevated WBC count
 - i. 1 Point: 3% chance of septic arthritis
 - ii. 2 Points: 40% chance of septic arthritis
 - iii. 3 Points: 93% chance of septic arthritis
 - iv. 4 Points: 99% chance of septic arthritis



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- b. Fever (>38.5C) is the best predictor of septic arthritis in children. C-reactive protein (CRP) >2 is also a strong indicator.
3. Discuss the treatment options for the top three diagnoses on the differential diagnosis.
 - a. Septic arthritis - Blood cultures (40-50% w/ positive result) computed tomography (CT) or ultrasound (US) to identify an effusion followed by aspiration. Intravenous antibiotics for 10-14 days. Oxacillin, Nafcillin, or Clindamycin. Cover for H. Influenzae if not vaccinated. Transient synovitis requires non-steroidal anti-inflammatory medications and rest.
 - b. Avascular necrosis (Legg-Calve-Perthes). Can see findings on plain film imaging but if high suspicion can obtain magnetic resonance imaging (MRI). Non-weight bearing and orthopedics consult or referral.
 - c. SCFE – treat with non-weight bearing and orthopedic referral.

Case 2: A 35-year-old male presents to the emergency department with knee pain. He was unable to walk at the time of injury and cannot do so now in the emergency department. He reports playing recreational soccer and reports a direct blow to the lower leg.

Question Prompts:

1. What physical examination features may help narrow down your diagnosis in this patient?
 - a. Ottawa knee rules – age >55, isolated tenderness of the patella, tenderness at the fibular head, unable to flex knee to 90 degrees, unable to bear weight both immediately and in the ED.
 - b. The Ottawa knee rules are designed to help guide ED management in regards to determining need for imaging.
2. How might your differential diagnosis shift if this patient had severe tibial pain and a more significant mechanism of injury?
 - a. Increased concern for a tibial plateau fracture, possible knee dislocation or subluxation.
3. Discuss various radiographic evaluations for knee pain and when each is most appropriate.
 - a. X-ray – when the patient does not meet the Ottawa Knee Rules or there is clear concern for bony injury.
 - b. CT – when there is high concern for fracture, which is not obvious on plain films. When there is a tibial plateau fracture, CT better defines the extent of injury and plans for immediate vs. delayed surgical intervention.
 - c. MRI can provide information on potential occult fractures when the patient remains unable to ambulate despite negative imaging.

Recommended Reading:

Kocher MS, Zurakowski D, Kasser JR. Differentiating between septic arthritis and transient synovitis of the hip in children: an evidence-based clinical prediction algorithm. *J Bone Joint Surg Am.* 1999;81(12):1662-1670.



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Knutson T, Bothwell J, Durbin R. Evaluation and management of traumatic knee injuries in the emergency department. *Emerg Med Clin North Am*. 2015;33(2):345-362. doi: 10.1016/j.emc.2014.12.007

Adhikari S, Blaivas M. Utility of bedside ultrasound to distinguish soft tissue abnormalities from joint effusions in the emergency department. *J Ultrasound Med*. 2010;29(4):519-526.

Key Learning Points

1. Fever (>38.5°C) is the best predictor of septic arthritis in children. CRP >2mg/dL was also a strong independent risk factor.
2. Application of Kocher criteria plus a CRP are the best way to identify septic arthritis in the pediatric patient.
3. Ottawa knee rules have been validated in both adults and children and can reduce ED imaging significantly. They are less specific and sensitive, however, than Pittsburgh criteria.
4. When tibial plateau fracture is suspected, orthopedic evaluation and strong consideration of CT is appropriate.

Knee dislocations, unlike patellar dislocations, should be considered limb threatening injuries due to vascular disruption. Vascular evaluation is always required for this injury.



Appendix B:

Non-Infectious Musculoskeletal Causes of Pain

Author: Robert Cooper, MD

Objectives

1. Review risk factors, pathophysiology, and the differential diagnosis for the presentation of compartment syndrome.
2. Recognize the signs and symptoms of both acute and chronic compartment syndrome.
3. Describe the steps in using a Stryker Intra-Compartmental Pressure Monitor and the different intra-compartmental pressure criteria used to make the diagnosis.
4. Review the varied presentations and risk factors for rhabdomyolysis.
5. Discuss the lab abnormalities associated with rhabdomyolysis and the treatment of rhabdomyolysis focusing on the role of bicarbonate.

Case Studies

Case 1: A 54-year-old male presents to the Emergency Department (ED) after his leg was caught between two doors for 3 hours. He complains of excruciating pain over his shin. The pain is worse with plantar flexion of his foot. On exam his shin is tender and the space between the tibia and fibula is firm. He has mild bony tenderness upon palpation and his calf is mildly tender. DP pulse is intact. His vitals show mild tachycardia and sensation is intact in his foot and shin. The patient is on lisinopril for hypertension and clopidogrel/salicylate for a history of coronary artery disease.

Question Prompts:

1. Describe your differential diagnosis and initial workup of this patient, specifically noting how the presence or absence of specific symptoms affects the differential diagnosis.
 - a. Compartment Syndrome occurs when a muscle is damaged causing increased intra-muscular fluid and an increase in fascial compartment pressure that eventually exceeds capillary pressure and results in ischemia.
 - b. Ischemic injury to muscle occurs after 4 hours with irreversible damage occurring between 6 and 8 hours of tissue ischemia.
 - c. The symptoms of compartment syndrome are classically defined as the “Six P’s,” pain out of proportion, pain on passive stretch, pallor, pulselessness, paralysis, paresthesia,” but the diagnosis is typically made on pain out of proportion and pain on passive stretch as the other P’s are late signs that occur after irreversible muscle damage has begun.
2. If the x-rays were negative for fracture of his tibia/fibula would this change your most likely diagnosis?



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- a. No, it is possible to still develop a compartment syndrome after prolonged compression or by simply laying on a hard surface for prolonged periods of time.
3. Are any laboratory or other invasive tests necessary prior to beginning definite management of this patient?
 - a. Compartment syndrome is a clinical diagnosis; however, it would be reasonable to check laboratory tests including a chemistry, CK level, and obtain measurements of the compartment pressure.
4. What are the most common areas affected by this diagnosis and what are risk factors for developing this diagnosis?
 - a. The most common areas for compartment syndrome are the below-knee compartments (anterior and deep posterior compartments) and the below-elbow compartments (volar compartment). Tibial fracture is the most common associated injury and radius/ulna fracture is the second most common injury. Compartment Syndrome can occur in any muscular compartment including the upper arm, thigh, hand, foot, buttocks, and even the rotator cuff
 - b. Causes of compartment syndrome include fractures, vascular injuries, soft tissue injury, and stab wounds.
 - c. Special care should be given to hemophiliac patients or individuals on anti-platelet/anticoagulants as this greatly increases the risk of bleeding resulting in compartment syndrome.

Case 2: A 24-year-old ultra-marathoner presents to the ED with excruciating left calf pain after completing a 40-mile training run. The patient's calf is tense and tender to palpation. DP pulses and lower extremity sensation are present. The patient's vitals show mild tachycardia and a blood pressure of 135/80. The patient is on no medications or supplements.

Question Prompts:

1. Describe the process of checking the compartment pressure in this patient, and what compartments should be checked?
 - a. When the diagnosis is suspected, all compressive dressings/casts should be removed and the limb should be elevated to the level of the heart.
 - b. The lower leg has 4 compartments that must be tested – anterior, lateral, superficial posterior, and deep posterior.
 - c. The forearm has 3 compartments that must be tested – superficial volar, deep volar, dorsal, and mobile wad.
2. What readings with the Stryker indicate that there is a likelihood of compartment syndrome?
 - a. The definitive diagnosis of compartment syndrome is made by using an Intra-Compartmental Pressure monitor. A pressure greater than 30mmHg is considered diagnostic; however, the **delta pressure** (diastolic blood pressure minus compartment pressure) is considered more sensitive with a delta pressure less than 20mmHg being a



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definite indication for fasciotomy, and a delta pressure less than 30mmHg being a relative indication.

3. If the patient instead was a runner with a several week history of anterolateral calf pain and a tense calf brought on by running and relieved with rest with a normal ED exam, what condition would you be concerned about and how would you work it up?
 - a. **Chronic Exertional Compartment Syndrome** is seen in athletes (most often runners or endurance athletes) who are symptom free at rest but have dull, achy pain and tightness on exertion. When symptomatic, the compartment may feel palpably tense.
 - b. The anterior or lateral compartment of leg are the most commonly affected.
 - c. The gold standard test is pre-exertion and post-exertion intracompartmental pressure testing.
 - d. If suspected in the ED the patient should be advised to refrain from strenuous activity and referred to sports medicine.

Case 3: A 66-year-old female presents with upper back pain worsening for several days. She has also felt warm. She denies trauma or inciting injury. Movement does not affect the pain. On exam she is tender over her latissimus dorsi and paraspinous muscles in her upper back. Her vital signs show mild hypertension and tachycardia. She is on amlodipine, furosemide, and atorvastatin. She admits to cocaine use as well.

Question Prompts:

1. Describe your differential and workup for this patient, specifically mentioning the risk factors she has for your #1 diagnosis.
 - a. **Myositis with Rhabdomyolysis** – Occurs with injury/necrosis to muscle fibers (caused by direct cell membrane damage and ATP depletion which leads to increased cytoplasmic calcium concentration causing myocyte destruction). The myocytes then release CK, myoglobin, etc into the circulation causing renal damage.
 - i. **Causes include** – alcohol, caffeine, **cocaine** (vasoconstriction), **Statins**, hypokalemia (vasoconstriction), crush injuries, prolonged down time, compartment syndrome, influenza A and B
 - ii. **Presentation** – Rhabdomyolysis should be suspected in patients who present with altered mental status and associated risk factors. Additionally, it should be suspected in patients found down, patients with muscle pain/weakness, patients with unexplained renal failure, and patients with tea colored urine.
2. Describe the lab findings and lab diagnostic criteria for this condition
 - a. The diagnosis of rhabdomyolysis is made by a fivefold increase in normal CK level which is >1000 U/L of CK. The classic finding on the UA is when the dipstick is positive for blood but there are no RBC's on the microscopy.
 - b. CK has a half-life of 1.5 days and is elevated in the first 12 hours.
 - c. Myoglobin serum half-life is only 1-3 hours so the absence of serum/urine myoglobin does not rule out the disease.



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- d. Serum CK level correlates well with the degree of muscle injury but does not correlate well with the risk of ARF; however, it is rare for patients with CK <5000 to develop renal complications.
3. What is the treatment for this condition and is there any role for additives to the primary treatment
 - a. Treatment of Rhabdomyolysis – Aggressive volume expansion with normal saline as most patients are dehydrated due to fluid shifts into the tissue. Aim for the patient to be making several cc/kg/hr of urine.
 - b. **Urine alkalization with bicarbonate** - no studies have shown any benefit to giving bicarb, but most authors still recommend that if a patient's urine is acidic you should add bicarb to the fluids. Normal saline causes a hyperchloremic metabolic acidosis so monitor pH and chloride levels.
 - c. Diuretics like mannitol and furosemide are not indicated.
4. List the serious complications of this condition and what the pathophysiology is behind these complications
 - a. Complications of Rhabdomyolysis – The most serious complication is **hyperkalemia** due to potassium release by myocytes. **Hypovolemia** is often seen as well due to movement into the damaged muscle and many patients may be 15L down. Renal failure due to myoglobin causing acute tubular necrosis (ATN).

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Key Learning Points: *Answers to the Discussion Questions Associated with the Case Studies



Appendix C:

Musculoskeletal Soft Tissue Infections

Author: Andrew King, MD, FACEP and Michael Barrie, MD

Objectives

1. Discuss the differential diagnosis of a red, warm extremity. Know differences in management when history includes water exposure in an ocean or lake.
2. Discuss the treatment options for cellulitis.
3. Discuss the differential for non-traumatic knee pain.
4. Discuss diagnosis and management of septic arthritis in the emergency department.
5. Discuss causes, physical exam findings, and management of hand infections including infectious tenosynovitis, felon and paronychia.

Case Studies

Case 1: A 55-year-old diabetic male presents to the emergency department with two days of progressive left lower extremity redness and swelling. The patient reports exquisite tenderness in the extremity. The patient is febrile and tachycardic. The extremity is red and swollen with a bluish discoloration in some areas. Bullae with a dark fluid are noted on the skin as well.

Question Prompts:

1. What is the differential diagnosis for this patient's presentation? Would it matter if the patient had recently vacationed at an ocean beach? How about a lake?
 - a. Cellulitis – strep, staph, vibrio, clostridium, plus many others. Necrotizing fasciitis, erysipelas, toxic epidermal necrolysis (TEN)/Steven Johnson, erythema multiform, pyoderma gangrenosum, deep vein thrombosis (DVT).
 - b. Exposure to ocean and fresh water result in additional pathogens to consider such as *Vibrio vulnificus* and aeromonas spp.
2. What is the underlying pathophysiology for this presumed infection? What diagnostic options are available?
 - a. A break in the skin allows bacteria access, which allows the pathologic features of the bacteria to cause spread. One can order laboratory testing for inflammatory markers (complete blood count (CBC), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP)), but are neither sensitive nor specific. Plain film x-rays could evaluate for tissue air, but computed tomography (CT) and magnetic resonance imaging (MRI) are more sensitive. Other modalities may be needed to rule out other causes such as a lower extremity duplex for DVT.



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3. Describe the treatment plan for this patient. What are your highest priorities? What are factors that influence disposition?
 - a. Antibiotics to cover for staph/strep should be initiated as soon as possible. If the patient is otherwise well appearing, oral antibiotics are reasonable as they have similar bioavailability to intravenous formulations. Ill appearing or complicated patients may require admission. Patient's with immunosuppression, such as diabetes, are at higher risk for failure on oral antibiotics and should be considered for admission. High-risk features such as concern for necrotizing fasciitis or ocean/water exposure should have low threshold to obtain a surgical consultation and admit on intravenous antibiotics for close monitoring. Observation status for some patients may be reasonable, but understand that many patients with high-risk features take longer than 24 hours on antibiotics to see improvement in symptoms.

Case 2: A 23-year-old female presents with a red, swollen left knee. She does have a past history of intravenous drug use. Her sexual history is somewhat vague but she admits to multiple recent partners. She denies vaginal symptoms. She is febrile and tachycardic with a late diastolic murmur. The knee is red and warm; she appears to keep the knee flexed to 45 degrees and resists any examination.

Question Prompts:

1. What differential diagnosis for this patient's condition?
 - a. Septic arthritis should be at top of differential, but one must also consider inflammatory arthritis, Reiter's syndrome, fracture/dislocation.
2. What is the major diagnostic consideration in this patient? How is this test used to distinguish the suspected diagnosis from other disease states? What is the role of blood cultures and other laboratory testing in this patient?
 - a. Clinicians could consider x-ray but they not required. If the patient is unable to passively range the joint, an arthrocentesis should be performed to evaluate for septic arthritis. Other findings such as fever, redness, warmth, elevated serum white blood count (WBC), CRP, and ESR are not sensitive enough to exclude this diagnosis. A finding on arthrocentesis of WBC>50,000 is most concerning and most specific for infectious arthritis; however, can still be present at much lower counts. Cultures should be obtained. Obtaining synovial lactate can be considered, but is still controversial.
3. What treatment should be initiated in the Emergency Department? What specific management strategies should you consider?
 - a. Emergent orthopedic consultation and arthrocentesis, which may help relieve some symptoms, and non-steroidal anti-inflammatory drugs (NSAIDs). Some orthopedic consultants prefer to avoid antibiotics until they can go to the operating room to provide the most sensitive culture; however, if the patient is systemically ill antibiotics should be considered after arthrocentesis.

Case 3: A 46-year-old female presents to the emergency department with swollen index and middle fingers on the right hand, which has increased in pain and intensity over the past 24 hours. She has no underlying



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medical conditions and notes that she was gardening several days before the onset of symptoms. The patient is afebrile. The two involved fingers are uniformly swollen and held in slight flexion. Any extension causes intense pain.

Question Prompts:

1. List potential sources of this patient's hand infection and describe the pathophysiology for this condition. Does it matter if the infection is primarily on the extensor or flexor surface of the hand?
 - a. Sources of infection include a penetrating wound such as a thorn directly into the deeper tissues of the hand.
 - b. Flexor injuries are generally more concerning.
2. What clinical findings are associated with this condition? What diagnostic studies are required for this patient? What is the disposition plan?
 - a. Flexor tenosynovitis can be diagnosed by Kanavels' signs – fingers held in slight flexion, uniform swelling over the affected tendon, tenderness to the affected tendon along its path, and pain with passive extension.
 - b. X-ray to evaluate for foreign body. ESR/CRP can be obtained but are neither sensitive nor specific. Obtain an emergent orthopedic consultation. If the diagnosis is confirmed, the patient would need urgent surgical exploration and admission for IV antibiotics.
3. Describe other significant infections of the hand and their management.
 - a. Paronychia – infection around the nail. This can be diagnosed clinically and relieved by sliding a scalpel under the nail fold to relieve the obstruction and allow purulence to drain. Could also use an 18g needle. In general these do not require a digital block however in some cases may be needed. Antibiotics are rarely required.
 - b. Felon – infection of the finger pad. Generally, more concerning than a paronychia. Require drainage. Incise the lateral aspect of the finger pad, avoiding cutting through the most distal portion of the finger pad. If the distal finger pad is incised (fish mouth I&D), then the finger pad will not heal correctly and patient may never regain full grip strength.
 - c. Herpetic whitlow – can mimic the above infections. Is a herpes infection of the finger. Incision and drainage is contraindicated. Should send viral cultures to confirm diagnosis.

Recommended Reading:

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Key Learning Points: *Answers to the Discussion Questions Associated with the Case Studies



Appendix D: Necrotizing Skin Infections

Authors: Colin Kaide, MD, FACEP and Michael Barrie, MD

Objectives

1. Contrast the various presentations of necrotizing fasciitis, Fournier's gangrene, and clostridial myonecrosis (gas gangrene).
2. Discuss the pathophysiology of necrotizing infections, including the role of clostridial alpha toxin.
3. What are the differences in microbiology in type I, type II, and type III necrotizing infections.
4. Discuss the diagnostic testing that is useful in making the diagnosis of necrotizing infection.
5. Discuss the surgical and medical management of necrotizing infections.

Case Studies

Case 1: A 25-year-old male presents with one day of a progressively worsening "cellulitis" on his arm. He got a small cut on his arm two days ago and noticed some mild redness on his arm. The redness has been getting progressively worse and has spread outside of the borders drawn earlier that day by an urgent care doctor. He said the pain was getting out of control. His blood pressure is 160 systolic and his heart rate is 120 beats/minute with a respiratory rate of 20. He is diaphoretic and anxious.

Question Prompts:

1. What are the range of organisms that are typically present in Type I and Type II, and slightly controversial, Type III necrotizing fasciitis (NF)?
 - a. Type I NF is a polymicrobial infection which tends to develop in older and sicker patients who have a history of chronic systemic disease such as peripheral vascular disease, immune compromise, or diabetes. Although the inciting factor can include various forms of skin trauma such as decubitus ulcers, postoperative wounds, animal or insect bites, or insulin injection sites, often there is no obvious source of injury and the cause is unclear.
 - i. The bacteria present in Type 1 NF include aerobic and anaerobic bacteria. Wound cultures frequently grow *S. aureus*, *E. coli*, *B. fragilis*, and various species of Enterococci, Peptostreptococcus, Prevotella, and Porphyromonas.
 - ii. *Clostridium perfringens*, the same organism that usually causes "gas gangrene," is often reported in type 1 NF. Recently though, it is less frequently being isolated in cultures of Type 1 NF.
 - iii. Group A, Beta-Hemolytic Strep (*Streptococcus pyogenes*) is usually also present. Fournier's gangrene, a form of NF that attacks the perineal region and abdominal wall, is also polymicrobial but enteric organisms predominate.



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- b. Type II NF accounts for only about 15-20% of cases. Type II NF can develop spontaneously in apparently healthy people who have no known causative factor or portal of entry for bacteria. In most patients, predisposing factors such as minor skin trauma and blunt injury can be identified. IV drug use has emerged as another significant cause of type 2 NF.
 - i. Group A Streptococcus
 - ii. Community-associated methicillin-resistant *S. aureus* (MRSA) has been increasingly reported as the sole organism.
 - c. Type III NF: Although not universally accepted, some experts use the designation of a Type III to describe a rare, very virulent form of NF caused by *Vibrio vulnificus*. This is seen in coastal communities and is associated with exposure of an open wound to warm seawater.
2. What historical and physical exam findings are seen in NF?
- a. Although uncommon, Necrotizing Fasciitis (NF) produces a life-threatening infection with a significant mortality rate despite maximal therapy.
 - b. NF is soft tissue infection that rapidly progresses to causes the necrosis of muscle fascia and subcutaneous tissues via many endotoxins, exotoxins and protease enzymes. They produce an expanding local tissue injury while also causing severe systemic toxicity.
 - c. The infection has been reported to spread at the rate of 1 inch (2.54 cm) per hour without manifesting overlying skin changes until the infection is in an advanced state.
 - d. Those who survive the initial infection frequently undergo multiple surgical debridements and sometimes amputations. This is usually followed by surgical reconstruction of the original infection sites, leading to significant ongoing morbidity.
 - e. NF tends to occur in in 2 different, but occasionally overlapping patterns. Each one is characterized by different organisms and typically affects different populations of patients.
 - f. The diagnosis can be either strikingly easy, or a really complicated diagnosis to make, depending on how advanced the infection is on presentation and how quickly one you recognize that this “particular cellulitis” doesn’t look like the others.
 - g. The classic presentation consisting of rapidly progressing pain, diaphoresis and anxiety in association with an injury or break in the skin, only seem to occur in 10-40% of the patients. Further, most patients do not present with shock, fever, altered mental status, and impending cardiovascular collapse.
 - h. If a patient does present with the characteristic findings along with fever and shock, NF should be strongly considered.
 - i. Most studies of presenting symptoms in NF look similar to cellulitis...erythema, swelling and pain. One striking feature that is often seen is tenderness beyond the margins of the apparently infected area.
 - j. The pain seems to be frequently “out of proportion” to a garden-variety cellulitis. This may be the only clue that there is a serious deep infection.
 - k. The later skin findings include blistering and bullae formation. In the final stages, the bullae convert to hemorrhagic bullae and skin anesthesia and necrosis can quickly follow.
 - l. The presence of crepitus and the issue of finding of gas on x-ray can be confusing. Various studies have reported crepitus in only 13% to 31% of patients presenting with NF.
3. What tests are useful in helping to make the diagnosis of NF?



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- a. Gas found on x-ray is very predictive of NF, but unfortunately it is a rare finding. CT is more sensitive for gas than x-ray and can show gas in the deeper tissue planes. Regardless of the imaging modality, gas is found in only 25% of NF. This seems to make sense since only a small number of the organisms involved in NF are gas formers.
 - i. Clostridium perfringens is a classic gas former but is only a component of the mix in Type 1 NF. If however, the patient does have crepitus on exam or gas is identified on imaging, the probability of NF is very high.
 - b. An elevated white count (>15,000); Low sodium (< 135); Other markers of inflammation are often elevated.
 - c. A scoring system was devised to help predict the presence of NF. This can help to appropriately risk stratify patients for whom you should strongly consider the diagnosis of NF. A total of less than 6 points confers a 96% negative predictive value for NF whereas a score of 6 or greater shows a positive predictive value of 92%.
 - i. Like all scoring systems, this one is not perfect. Subsequent, albeit less well-done, studies have challenged the degree of predictive value of the system. Regardless, this system is another tool to help make the case for rapid evaluation by a surgeon for definitive surgical diagnosis and definitive treatment.
4. What is the significance of finding or not finding gas in the tissues on x-ray?
- a. Plain x-rays showing gas in the tissues is very convincing for NF; however, it is a big mistake to assume that the absence of gas rules out NF. Gas on x-ray or even on computed tomography (CT) is found in only about 25% of cases.
 - b. When NF is suspected but not yet clearly identified to such a degree as to convince a surgeon to take the patient to the OR, imaging can be helpful. Overall, imaging studies are not perfect and are generally only indicated in cases in which the diagnosis is questionable. Obvious cases of NF do not need things to get between them and cold, hard surgical steel!
 - c. CT can demonstrate fluid collections and inflammatory changes consistent with possible NF and its sensitivity is quoted as high as 80%.
 - d. Magnetic resonance imaging (MRI) remains the most definitive imaging modality with sensitivities of 90-100%.
5. What are the roles of surgical debridement, antibiotics and hyperbaric oxygen in the treatment of NF?
- a. **Surgery:** Definitive treatment for NF is surgical debridement. The mortality of NF is directly proportional to the duration of delay in getting the patient to the operating room. Delays of 24 hours confer a 9 fold increase in mortality. A recent Australian study described a clear correlation with survival and early surgical debridement.
 - b. **Antibiotics:** Antibiotic therapy is not definitive, as antibiotics do not penetrate into the areas of active infection. It is however very important in the treatment of sepsis and in helping to control the spread of the disease. Empiric therapy should include coverage for MRSA and MSSA along with gram negative and anaerobic bacteria. Piperacillin/tazobactam plus vancomycin with the addition of clindamycin is a typical regimen. Clindamycin decreases



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- the elaboration of certain toxins specifically Clostridial alpha-toxin and M-proteins expressed by Strep and Staph.
- c. Hyperbaric Oxygen: Hyperbaric Oxygen Therapy (HBO) creates a hyperoxic environment by subjecting the entire patient's body to 100% oxygen at pressures of 2.5-3 atmospheres absolute. Inhaled oxygen at these pressures generates a partial pressure of oxygen as high as 2200 mmHg. At this PaO₂, some physiologic and biochemical changes that can have a significant antibacterial effect. HBO is an adjunctive treatment only. It should never delay definitive surgical therapy. It is best used after debridement. Studies to date have shown a decrease in mortality, number of surgical re-debridements and a decrease in amputations when HBO is added to aggressive surgery. In centers where HBO is readily available, it should be considered. These include:
 - i. Suppression of clostridial alpha toxin production in gas gangrene
 - ii. Enhancement of leukocyte-killing activity.
 - iii. Bacterial growth suppression in hyperoxic tissues.
 - iv. Improved antibiotic efficacy in a hyperoxic environment. (Aminoglycosides, trimethoprim, sulfamethoxazole, sulfasoxazole).
 - v. Hypoxic environments decrease the effectiveness of fluoroquinolones and vancomycin. This can be reversed by HBO. Improvement in tissue repair. Suppression of the anaerobic bacteria.

Case 2: A 56-year-old male diabetic patient presents with complaints of scrotal swelling and pain. He noticed some redness on his scrotum over the last few days and it became acutely worse today. He has obvious violaceous blebs on his perineum.

Question Prompts:

1. How does this disease process compare and contrast to classic NF (organisms, affected population, comorbidities, etc)?
 - a. Fournier's Gangrene should be considered as a polymicrobial NF of the scrotum/perineum.
 - b. More common in immunocompromised patients, diabetics, and renal failure patients on dialysis.
 - c. Time is scrotum (and abdominal wall).
2. What is the usual diagnostic testing involved in this entity?
 - a. Diagnosis is clinical and does not require imaging to mobilize surgical intervention; however, if diagnosis is in doubt, CT or MRI can better define extent of infection.

Case 3: A 43-year-old healthy male presents with hypotension, tachycardia, diaphoresis and a feeling of impending doom. He has a wound on his leg that happened when he fell off of his bike and impaled his leg on a stick. He pulled the stick out and cleaned the wound and bandaged it. This happened three days ago. An X-ray shows gas in the tissues.



Case courtesy of Dr Kewal Arunkumar Mistry, Radiopaedia.org, rID: 35409

Question Prompts:

1. What organism is the most likely culprit and what is the usual source?
 - a. Gas gangrene is caused by various species of Clostridium.
 - b. Gas gangrene is a rapidly progressive, invasive clostridial infection of previously healthy muscle tissue. It is also known as clostridial myonecrosis. It produces massive local tissue destruction along with severe systemic symptoms.
 - c. These are Gram-positive, spore-forming, anaerobic rods normally found in soil and the human and animal gastrointestinal tract.
 - d. The most common species implicated in gas gangrene is Clostridium perfringens (80%–90%). This organism is the causative agent in traumatic and postsurgical cases. Direct inoculation of a traumatic wound with C perfringens in a hypoxic wound environment with a compromised blood supply is the perfect milieu for growth. Many traumatic wounds are contaminated with Clostridium spores, but only a small percentage actually develop gas gangrene. It seems that both inoculation with the organism and a relatively hypoxic tissue environment are necessary for the clinical disease process to develop.
 - e. The clinical syndrome of infection with C perfringens begins with pain at the infection site that seems out of proportion to the size of the wounded area. Local tissue destruction results in bleb and bullae formation. Rapid extension of the wound almost seems to happen in real time, at rates up to 15 cm/hour.
 - f. When present, gas can sometimes be seen on radiographs and felt in the tissue as crepitus. In at least 50% of cases, however, gas is not demonstrable, either on radiographs or



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- clinically. Owing to variability, the detection of gas should not be used to make or break the diagnosis of clostridial infection.
- g. A “sickly sweet” odor can be detected from the wound drainage.
 - h. Systemic symptoms include a low-grade fever, disproportionate tachycardia (140–160), and cognitive symptoms ranging from a flat affect to severe anxiety. Hypotension is a late finding and heralds impending circulatory collapse and death.
 - i. Clostridium spreads rapidly in the tissue not so much as a function of bacterial replication but rather by the elaboration of many exotoxins. These various toxins break down connective tissue, lyse blood components, and cause necrosis of muscle tissue. Systemic effects are also seen, including shock, myocardial depression, capillary leaking, renal failure, and death.
2. What is the toxin that causes most of the problems with this infection?
 - a. The most clinically important of the toxins seems to be alpha-toxin.
 3. What is the treatment for this infection?
 - a. Broad-spectrum antibiotics, surgical debridement, and consider hyperbaric oxygen therapy.

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Key Learning Points: *Answers to the Discussion Questions Associated with the Case Studies



Appendix E:

Lower Extremity Injuries

Author: Andrew King, MD, FACEP

Objectives

1. Describe the mechanism, workup and management of a toddler's fracture.
2. Describe risk factors for slipped capital femoral epiphysis (SCFE).
3. Describe diagnosis and management of compartment syndrome.
4. Describe early and late symptoms/findings of compartment syndrome.
5. Discuss clinical decision rules for obtaining imaging in patients with ankle pain.
6. Define a Jones fracture and a Lisfranc fracture. Discuss emergent management of these conditions.

Case Studies

Case 1: A 2-year-old male patient presents with his parents to the emergency department after refusing to walk. Parents report that the child is extremely active but has been refusing to walk since last evening. He seems to be favoring his right leg, and his parents state that he is a typical toddler who runs into everything and falls frequently. They have administered both Tylenol and ibuprofen without improvement or successful ambulation. Child stays home with his mother during the day. Child cries when examining his lower right leg and refuses to walk.



Case courtesy of Dr Jeremy Jones, Radiopaedia.org, rID: 9317



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Question Prompts:

1. What is the most appropriate diagnostic evaluation for this child?
 - a. Thorough history and physical examination, and then x-rays of the affected extremities.
2. What is the likely fracture affecting this particular child?
 - a. Toddler's fracture which is typically the result of minor trauma associated with the activity of a toddler. True spiral fractures of the tibia must result in a non-accidental trauma evaluation.
3. Describe the management of this fracture?
 - a. Place in a splint or above the knee walking cast, and have follow up with orthopedics. Treatment is generally supportive and non-operative.

Case 2: A 12-year-old obese male presents to the emergency department complaining of left knee and groin pain for the past several days. He is currently ambulating with a limp. No paresthesias or weakness are reported. He denies injury. Physical examination reveals pain with log rolling of the left hip. Remainder of his lower extremity examination is unremarkable. On ambulation, the patient exhibits an obvious limp.



Case courtesy of A.Prof Frank Gaillard, Radiopaedia.org, rID: 10357

Question Prompts:

1. Describe the pathophysiology of this child's diagnosis.
 - a. The patient likely has a slipped capital femoral epiphysis (SCFE). This is when the femoral epiphysis "falls off" for reasons that are not well understood. The major risk factor is obesity. This injury is at risk for avascular necrosis and chronic arthritis.
2. What imaging study should be performed if the initial pelvis/hip films are normal?



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- a. Frog-leg lateral view on hip films is diagnostic for SCFE, especially when other views are normal.
3. What is the appropriate management of this condition?
 - a. Immediate non-weight bearing and orthopedics consultation for likely surgery depending on degree of injury.

Case 3: A 35-year old female presents to the emergency department via EMS after a motor vehicle collision. The patient was a restrained driver and complains of severe pain to her right leg, which she struck on the dashboard. There is an obvious deformity of the lower leg on physical examination, and the fracture appears to be open. She complains of severe pain on palpation of the entire lower leg, and states that the entire lower leg is numb. Examination also reveals some pallor to the right leg. Orthopedics asks you to check for compartment syndrome



Case courtesy of Dr Sajoscha Sorrentino, Radiopaedia.org, rID: 15121

Question Prompts:

1. What history, exam findings, and compartment pressures are indicative of compartment syndrome?
 - a. Early signs of compartment syndrome include pain, paresthesia, and pallor. Late signs include paralysis and pulselessness. Compartment pressures over 30 mmHg indicate compartment syndrome. Must have a high index of suspicion with tibial fractures.
2. If the anterior compartment pressure is 30 mmHg, what is the next step?
 - a. Consult an orthopedic surgeon and plan for immediate fasciotomy.



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- b. Delta pressure (diastolic blood pressure minus compartment pressure) is considered more sensitive with a delta pressure less than 20mmHg being a definite indication for fasciotomy, and a delta pressure less than 30mmHg being a relative indication.
 3. What are important principles of a thorough musculoskeletal assessment?
 - a. Neurovascular examination is paramount in all patients with orthopedic injuries.
 - b. Image a joint above and a joint below injury
 - c. Aggressive pain control is necessary for these patients. Consider valium for patients with femur fractures as some of their pain is due to spasm of the large muscle groups
 - d. Hip fractures have high associated morbidity and mortality

Case 4: A 26-year-old male basketball player presents to the emergency department complaining of left foot pain after a collision during his last basketball game. Pain is worst with ambulation and notes that the pain is worst on the lateral aspect of his foot. No parasthesias or weakness and is able to walk with pain. No ankle or knee pain. Patient has pain on palpation of the base of the 5th metatarsal and lacks pain on ankle examination. Thompson test is negative.



Case courtesy of A.Prof Frank Gaillard, Radiopaedia.org, rID: 12641

Question Prompts:

1. What is the likely specific injury affecting this patient?
 - a. Jones Fracture
2. Why must these patients be seen by orthopedics emergently?
 - a. Jones and Lisfranc fractures require emergent orthopedic evaluation as delayed treatment can result in permanent disability.
3. What is the emergency department treatment for this patient and what instructions must be given?



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- a. Place patient in a fracture boot and strict non-weight bearing. Ensure follow up with podiatry or orthopedic surgery.
4. What are other important aspects of a thorough ankle and knee exam?
 - a. Examination of the extensor mechanism with patellar fractures is vital, otherwise will require emergent orthopedic evaluation.
 - b. Must examine the fibular head with ankle injuries to assess for syndesmotic injury.
 - c. On evaluation of ankle imaging, pay special attention to the mortise. Lack of uniformity of the mortise indicates a fracture or dislocation.

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Key Learning Points: *Answers to the Discussion Questions Associated with the Case Studies



Appendix F:

Upper Extremity Injuries

Author: Andrew King, MD, FACEP

Objectives

1. Discuss the diagnosis and management of pediatric elbow fractures.
2. Summarize the Salter-Harris classification of pediatric fractures.
3. Discuss common (and commonly tested) fractures/dislocations in ED patients with traumatic wrist and forearm pain. Namely, Scaphoid fractures, Lunate/perilunate dislocation, Monteggia vs. Galeazzi fractures.
4. Discuss how to perform a hand physical exam.
5. Describe commonly damaged structures resulting from an anterior shoulder dislocation.
6. Discuss what types of injuries require an ED orthopedics consult.

Case Studies

Case 1: A 6-year-old girl presents with her parents to the emergency department after falling off the monkey bars at school. Parents report that the child fell onto her left arm today into a bed of mulch while on recess. She has pain to her left elbow and refuses to move. They have administered both Tylenol and ibuprofen without improvement. She has no other injury and denies parasthesias. She is able to move all of her fingers and there is pain with palpation of the left elbow and she refuses to move on examination.

Question Prompts:

1. What is the most appropriate diagnostic evaluation for this child?
 - a. Thorough history and physical examination including a neurovascular exam. X-rays of the elbow, forearm, and wrist would likely be appropriate.
2. What is the likely fracture affecting this particular child?
 - a. Supracondylar fracture. Would also consider Monteggia fracture (ulnar shaft fracture with radial head dislocation) and Galeazzi fracture (radius fracture with distal ulnar dislocation).
3. Describe the Salter-Harris Classification.
 - a. (Same) I: Xrays negative, exam only indicative with pain over joint and suggestive mechanism of injury.
 - b. (Above) II: Fracture involves the Metaphysis through the Pysis. 75% of pediatric fractures involving a joint are classified as SH II.
 - c. (Lower) III: Fracture involves the Pysis through to the Epiphysis. These fractures are more serious therefore refer early.
 - d. (Through) IV: Fracture involves the Epiphysis, Pysis, and the Metaphysis. These require emergent referral.



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- e. (Every-physis Ruined) V: compression of the Physis. It is usually diagnosed when growth arrest is noticed after injury is diagnosed as a SH I or missed entirely
- 4. Describe the management of this fracture? What if there was displacement?
 - a. Orthopedic evaluation, splint/cast to immobilize the elbow
 - b. Displacement requires reduction or orthopedic open fixation
- 5. What are the important neurovascular structures affected by this fracture?
 - a. Tear or entrapment of the brachial artery and median nerve compression. This can lead to a compartment syndrome (Volkmann's contracture).
- 6. What is the most sensitive imaging finding for these fractures?
 - a. "Sail Signs" – a posterior fat pad is always pathologic

Case 2: A 22-year-old female presents to the emergency department complaining of left thumb and wrist pain after falling onto her arm. Pain is worst with movement and she states that the swelling has increased since the injury earlier in the day. No paresthesias or weakness are reported. Physical examination reveals pain with axial loading of the thumb and on palpation of the radial aspect of the wrist.

Question Prompts:

- 1. What fracture are you concerned about with this clinical presentation?
 - a. Scaphoid (Navicular) fracture
- 2. What imaging study should be performed if wrist films are normal?
 - a. MRI or CT are reasonable options if initial imaging is negative. Otherwise, placing the patient in a thumb spica splint and having them follow up in 7-10 days for repeat imaging may also diagnose fractures.
- 3. What is the appropriate management of this condition with normal imaging and pain? What is the appropriate management if a fracture is identified?
 - a. Patients should be placed in a thumb spica splint regardless of imaging being positive or negative if pain is present. Definitive fractures should follow up with a hand specialist.
- 4. Why do these fractures require emergent orthopedic attention?
 - a. Concern for avascular necrosis, which can result in permanent morbidity.

Case 3: A 57-year old male presents to the emergency department via EMS complaining of pain to his right hand and fist after a heavy piece of machinery fell onto his hand. He states that he is unable to make a fist and has tingling in the ulnar nerve distribution. Imaging is shown below.



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Case courtesy of Dr Andrew Dixon, Radiopaedia.org, rID: 9906

Question Prompts:

1. What injury is described in this clinical presentation and imaging?
 - a. Lunate dislocation
2. What is the ED management of this injury and when should orthopedics evaluate this patient?
 - a. Patient should have emergent reduction performed in the ED and urgent orthopedic evaluation for likely surgery.
3. What are the radiographic differences between this injury and another wrist dislocation?
 - a. Peri-lunate dislocation maintains the normal lunate to radius alignment.

Case 4: An 18-year-old male presents to the emergency department complaining of left shoulder pain after a collision during a football game. Pain is worst with movement and he is refusing to move his arm holding it close to his torso. No parasthesias or weakness and he has had no similar injury. He has full range of motion of his fingers and is completely neurovascularly intact. He has a squared-off deformity to the shoulder on examination.

Question Prompts:

1. What is the likely injury affecting this patient?
 - a. Anterior shoulder dislocation
2. Describe a Hill-Sacks deformity and Bankart lesion.
 - a. These are findings that are commonly present after a shoulder dislocation and reduction. A hill-sacks deformity is a humeral head crush fracture from the humerus being pushed into the coracoid process. A bankart lesion is a tear of the anterior/inferior glenoid labrum caused by the dislocation.
3. What is the most commonly damaged structure in anterior shoulder dislocations and reductions?



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- a. Axillary nerve injury is a common complication of shoulder dislocations. This should be assessed by testing sensation over the deltoid.

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Key Learning Points: *Answers to the Discussion Questions Associated with the Case Studies



Appendix G:

Diagnostic Approach to Cervical and Lower Back Pain

Authors: Robert Cooper, MD and Michael Barrie, MD

Objectives

1. Review pathophysiology, differential diagnosis, and diagnostic modalities for the presentation of back pain.
2. Utilize the available evidence-based medicine (EBM) literature to develop an algorithm for risk stratifying patients presenting with back pain.
3. Discuss the physical exam of the patient presenting with low back pain, specifically focusing on physical exam tests that can identify nerve root compression.
4. Understand the differences between the 2 clinical decision rules available for c spine clearance.
5. Utilize the available EBM literature to develop a strategy for pain control in patients with lower back pain.

Case Studies

Case 1: A 54-year-old male presents to the ED complaining of low back pain. It started earlier in the day and is worse in his right lumbar paraspinous area and in his lumbar spine. He states the pain radiates to his right abdomen at times. He denies any trauma or provoking mechanism. He states his urine has been darker. His vital signs are 155/95, HR 95, 98% SPO2, and afebrile. On exam he is tender to his right lumbar paraspinous area and over L3-L5. He has no neurologic deficits.

Question Prompts:

1. Describe your approach to risk stratifying the patient who presents with low back pain. What history features help you risk stratify ED patients with lumbar back pain? Discuss the key components of physical exam in patients presenting with lower back pain. List a differential diagnosis for back pain.
 - a. Patients with low back pain can be stratified into 3 categories - Patients with pain related to another medical condition, patients with lumbar radiculopathy, and patients with non-specific back pain (85% of patients).
 - b. Medical Conditions that can mimic back pain include – abdominal aortic aneurysm (AAA), ectopic pregnancy, renal colic, aortic dissection, retroperitoneal hemorrhage, and pancreatitis.
 - c. Patients with radiculopathy must be assessed for nerve root involvement with an extensive physical exam specifically looking at the L4, L5, and S1 nerve roots
 - d. Physical exam of the back should include inspection, palpation, percussion, and gait. More specific tests include:



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- i. Straight leg raise – Positive when pain radiates below the knee in a dermatomal distribution. 92% sensitive, 28% specific
 - ii. Extensor hallucis longus testing – L5 - Extension of the great toe against resistance tests the L5 nerve root, which is the most common nerve root affected by disc herniation.
 - iii. Plantar flexion / toe raises – test S1 nerve root. Unilateral toe raises while standing are more sensitive than having the patient plantar flex their foot while laying in bed
 - e. Reflexes – Nerve root compression causes variable changes in reflexes and the presence of reflexes does not mean the patient is free of nerve root compression
 - i. L3/L4 – patellar reflex
 - ii. L5 – none
 - iii. S1 – ankle reflex
 - f. Rectal exam – very difficult to adequately judge rectal tone, however needs to be documented in patients with signs or symptoms of cord compression
2. What are red flag historical features and symptoms that you would elicit during your history taking of this patient?
 - a. Age under 18 (more likely to be tumor or congenital disorder) or over 50 (tumor/AAA/infection)
 - b. Duration greater than 6 weeks at which point back pain is no longer considered acute and imaging should be obtained
 - c. Fever/chills/weight loss
 - d. Cancer history
 - e. History of immunosuppression, especially steroids
 - f. Intravenous (IV) drug abuse
 - g. Anticoagulation – spontaneous hemorrhage in spine causing compression
3. Which non-back/spine diagnoses is this patient at risk for?
 - a. Due to his age and being male, would want to consider AAA. Also could be kidney stone, less likely pyelonephritis.
4. Would you image this patient and if so which modality would you choose? If the patient had cancer would this change your choice?
 - a. There is not perfect right answer for this patient as not all providers would follow the same diagnostic algorithm. Also, more history (such as history of intravenous drug abuse (IVDA)) could help sway the workup. In general, patients with localized symptoms of back pain and concern for pathology require a magnetic resonance imaging (MRI) of the lumbar (or other affected area) spine. A computed tomography (CT) scan is sensitive for fracture but not other spinal pathology. A history of malignancy would increase pre-test probability of having a finding on MRI.

Case 2: A 22-year-old male presents after an motor vehicle collision (MVC) in which he was the restrained driver. He was stopped at a stop sign when he was rear-ended. The other car was travelling about 20 miles per hour. Airbags were not deployed and there is minimal damage to both vehicles. He complains of cervical and lumbar back pain. He denies any neurologic symptoms, loss of consciousness, vomiting, or amnesia. On



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exam he has cervical spinal tenderness to palpation over C3-C4 and cervical paraspinous tenderness to palpation. He can turn his neck side to side with minimal pain. He also has tenderness to palpation over L3-L4 with no step off and no deformity.

Question Prompts:

1. Describe any clinical decision rule you could use you to guide your diagnostic workup of this patient.
 - a. Not all patients with trauma and c-spine tenderness require imaging. The Canadian C-spine rule (equal sensitivity to nexus and better specificity) allows clearance of patients with midline cervical tenderness to palpation who have one of five low risk factors: simple rear-end MVC, sitting position in ED, ambulatory at any time, delayed onset of neck pain, or absence of midline c-spine tenderness to palpation and who can rotate their neck 45 degrees to the left and right.
2. What imaging would you order on this patient?
 - a. CT cervical spine is the preferred imaging modality in trauma patients. It is more sensitive and specific than plain radiographs.
3. If the imaging ordered was negative but the patient had persistent c spine pain, describe the process you would use to clear the c spine.
 - a. If the patient still has a concerning exam for spinal injury after negative adequate X-ray or CT, then one option is to obtain flexion/extension views to test for unstable ligamentous injury. If normal, then can place patient in a c-collar and discharge home with spine follow up or until pain resolves. Alternatively, if suspicious is high for ligamentous injury a MRI of the cervical spine can be obtained.
4. Discuss indications for imaging in patients with traumatic lumbar back pain.
 - a. If patient has point tenderness to the lumbar spine and a high-risk mechanism, it is reasonable to obtain imaging in these patients. All risk patients should have CT imaging to rule out fracture. Lower risk patients could have a lumbar x-ray, however this has lower sensitivity compared to CT. MRI should be used as first line for patients with non-traumatic lower back pain that have red flags in history or exam (see above).

Case 3: A 66-year-old female presents with low back pain after helping her grandson move. She states the pain is across her lower back with no radiation. She has no red flag symptoms and denies trauma. She takes medications for hypertension and diabetes and has a history of CAD. Her vitals are normal and her exam shows paraspinous lumbar tenderness to palpation with a normal neuro exam and ambulation with mild pain.

Question Prompts:

1. What is your first line treatment for this patient?
 - a. There is conflicting evidence of whether non-steroidal anti-inflammatory drugs (NSAIDS) are better than Tylenol for low back pain. Generally NSAIDS are preferred but in older adults



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- Tylenol may be preferred as NSAIDs increase the risk of MI and stroke in addition to GI bleed and renal injury.
- b. Tramadol has not been shown to relieve low back pain.
 - c. Evidence on muscle relaxants is mixed and they likely do not help with back pain
 - d. Steroids should only be used for sciatica, in patients without diabetes
2. What historical factor(s) does this patient have that would influence your treatment choice?
 - a. Due to her age and history of diabetes, steroids should be avoided. Also, NSAIDs in the elderly should be used very cautiously as more likely to cause renal injury.
 3. Would you prescribe a muscle relaxant?
 - a. In general, muscle relaxants have not been shown to have any benefit in randomized controlled trials. Valium may have increased benefit compared to cyclobenzaprine.
 4. At what point would you prescribe a narcotic and would tramadol be an option?
 - a. In general, these should be avoided in the treatment of lumbar back pain. See above.

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Key Learning Points: *Answers to the Discussion Questions Associated with the Case Studies



Appendix H:

High Risk Back Pain

Authors: Robert Cooper, MD and Michael Barrie, MD

Objectives

1. Review pathophysiology, differential diagnosis, and diagnostic modalities for the presentation of high risk etiologies of back pain
2. Discuss questions posed by residents in their pre-work assignments
3. Utilize the available EBM literature to discuss the diagnosis of Spinal Epidural Abscess
4. Discuss the utility of the various historical factors and tests available to risk stratify the patient with possible Cauda Equina Syndrome
5. Discuss the physical exam tests to diagnose sciatica and the use of steroids in the treatment of sciatica
6. Summarize key learning points.

Case Studies

Case 1: A 25-year-old female with multiple visits for back pain presents with lower back pain. She states it starts 3 days ago and is localized to her lower back both along the spine and the paraspinal muscles. She denies loss of bowel or bladder control, saddle anesthesia, or radiation to her legs. She endorses intermittent heroin use. She states she feels like she's had fever and chills at home. She has the following vitals: 120/70, 90, 99.8, and has tenderness over her lumbar spine with normal skin appearance. The rest of her physical exam is normal.

Question Prompts:

1. List a prioritized differential diagnosis for this patient
 - a. Spinal epidural abscess, psoas abscess, discitis, lumbar disc herniation, vertebral compression fracture.
 - b. Spinal Epidural Abscess (SEA) usually occurs from hematogenous spread, extension of nearby infection, or iatrogenic inoculation. The lesions are typically associated with vertebral osteomyelitis. Lesions most often occur in the lumbar region. The classic triad of fever, back pain, and neurologic deficits occurs in only about 13% of patients with SEA and most patients have normal neurological exams.
2. Besides IV drug abuse, what other historical questions would you ask to risk stratify this patient?
 - a. Most patients with SEA had one of the following risk factors – diabetes mellitus, intravenous (IV) drug abuse, chronic kidney/liver disease, recent spinal procedure or indwelling hardware, immunocompromised state, or other site of infection. All IV drug users with fever and back pain should be worked up for SEA.



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3. What laboratory tests would you order on this patient and which is the most sensitive?
 - a. Erythrocyte sedimentation rate (ESR) has a better sensitivity and specificity for SEA than C-reactive protein (CRP) and was greater than 20 mm/hr in most patients with SEA compared to elevation in only some patients without SEA. The definitive test for SEA is magnetic resonance imaging (MRI) of the entire spine with contrast.
4. Would you obtain imaging on this patient, and if so which modality?
 - a. Yes. MRI of the entire spine with contrast.

Case 2: A 50-year-old male with a history of known lumbar herniated disc presents to the ED complaining of worsening lower back pain with radiation down his bilateral posterior legs, which is new. On further questioning he endorses that he has new urinary frequency and has feeling of bladder fullness. He denies saddle anesthesia or leg weakness. He denies fever or chills.

Question Prompts:

1. Describe the significance of bilateral sciatica with relation to the pathophysiology of the disease entity for which you are most concerned.
 - a. The 2 high-risk historical factors that increase the pretest probability of Cauda Equina Syndrome (CES) are bilateral sciatica and new urinary symptoms. Many patients with CES have some degree of urinary dysfunction but the dysfunction is just as likely to be retention or frequent urination as incontinence. Any new urinary symptoms in the setting of back pain should prompt a workup for CES.
2. Which physical exam maneuvers are indicated in this patient and how sensitive and specific are they?
 - a. Rectal tone and a post void residual are useful if they are abnormal but normal findings cannot be used to rule out CES. Rectal tone in particular has low sensitivity and specificity but from a medico-legal perspective should be documented.
 - b. Cauda Equina Syndrome (CES) is due to nerve root compression of the distal lumbar and sacral nerve roots.
3. Is overflow incontinence the only urinary symptom that would raise your pretest probability for serious disease?
 - a. It is classically associated with urinary or fecal incontinence and saddle anesthesia.
 - b. Half of patients with CES present with urinary retention while the rest have an incomplete syndrome. It is important to identify patients prior to urinary retention because at this point the odds of both permanent neurological disability and a plaintiff award in a lawsuit increase dramatically.

Case 3: A 45-year-old male who works as a laborer presents to the ED with right-sided lumbosacral back pain. It's been getting worse for several days while he has been doing lifting at work. He states the pain is just above his right buttock and runs down the back of his leg almost to his foot. He denies any loss of bowel or bladder control, saddle anesthesia, or fevers. His vitals are normal.



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Question Prompts:

1. Describe the straight leg raise and crossed straight leg raise test
 - a. A positive straight leg raise test must reproduce pain radiating below the knee in a L4/L5/S1 distribution.
2. What other physical exam maneuvers would you want to perform in order to test the involved nerve roots?
 - a. Careful neurologic exam including strength in the lower extremities, reflexes at the knee and ankle, and distal perfusion.
 - b. Testing the extensor hallucis longus by great toe dorsiflexion and ankle strength by toe raises is important diagnostically as these test the L5 and S1 nerves respectively.
3. What medications would you prescribe this patient for pain relief?
 - a. Sciatica is the only instance for which steroids may help reduce the intensity and duration of low back pain.
4. If the patient had bilateral leg pain, no neurologic signs, and pain worse with walking and relieved by sitting, how would you change your diagnosis and treatment plan?
 - a. Spinal stenosis is a common source of back pain in the elderly caused by spinal canal narrowing. It typically involves pain radiating to both legs. It is worse with standing/walking and is relieved by sitting and forward flexion. It will typically get better with analgesia and rest but will reoccur without surgery.
 - b. Sciatica is most commonly caused by disk rupture or osteoarthritic change at the level of the L4-L5 or L5-S1 nerve root. Sciatic pain radiates along a broad line from the middle or lower buttock and proceeds dorsolaterally in the case of L5 nerve root involvement or posteriorly in cases of S1 compression. Sensory symptoms including paresthesias are less prominent than pain.

Recommended Reading:

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DeLaney M. High risk back pain: spinal epidural abscess. *Academic Life in Emergency Medicine*. <https://www.aliem.com/2014/high-risk-back-pain-spinal-epidural-abscess/>. Published September 25, 2014. Updated December 18, 2015. Accessed October 10, 2016.

Williams CM, Henschke N, Maher CG et al. Red flags to screen for vertebral fracture in patients presenting with low-back pain. *Cochrane Database Syst. Rev.* 2013;(1):CD0086.



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DeLaney M. High risk back pain: spinal epidural abscess. Academic Life in Emergency Medicine. <https://www.aliem.com/2014/high-risk-back-pain-spinal-epidural-abscess/>. Published September 25, 2014. Updated December 18, 2015. Accessed October 10, 2016.

Key Learning Points: *Answers to the Discussion Questions Associated with the Case Studies