



THE UNIVERSITY OF ARIZONA
COLLEGE OF MEDICINE TUCSON

Pediatrics



Musculoskeletal Infections in Children

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Disclosures

- I have no conflicts of interest to disclose

Objectives

- Recognize the signs and symptoms of serious bacterial musculoskeletal infection in children
- Choose and interpret the appropriate diagnostic tests
- Choose appropriate antibiotic therapy for MSK infection

Is This a Musculoskeletal Infection?

- Healthy 15 y/o male presents with fever and shoulder pain
 - Has been lifting weights and playing basketball
 - No known MSK injury
 - On exam
 - Temp of 100.6, congestion and mild cough, diffuse pulmonary crackles, mild tenderness along the proximal biceps
 - WBC 21 (neutrophil predominant)
 - Mycoplasma IgM positive
 - Prescribed azithromycin and sent home
 - Does this sound reasonable?
 - Respiratory symptoms likely driving the clinical picture
 - Can't exactly explain the biceps pain, but could easily be attributed to activity/injury

Few Days Later.....

- Respiratory symptoms improved, but
- Pain intensity increased and is spreading along the arm
- Fever worse
- Is there something more going on here?
- What would you do now?

Sorting Out MSK Infection in Children

- Site of infection
 - Bone
 - Joint
 - Muscle
 - Combination
- Bacterial vs fungal vs viral vs post infectious causes
- Signs/symptoms/findings
 - Timing/rapidity of onset/progression
 - Severity
 - Red flags
- Exposures

MSK Infection Red Flags

- Sepsis
- Severe/rapid progression
- Fever + MSK pain = concern enough to evaluate
 - Point tenderness = increased risk
 - Can you find a plausible non-infectious explanation?
 - Can you also explain away the fever with a non-MSK infectious cause?
 - Elevated WBC/inflammatory markers = increased risk
- Need definitive testing with high-risk scenarios
 - Imaging, cultures, other diagnostics
 - Possible empiric treatment depending on severity

Imaging For Pediatric MSK Infection

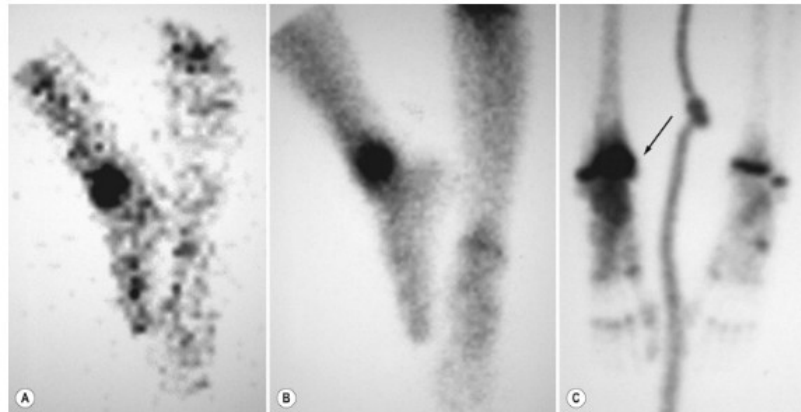
- Xray: will almost always start here
 - Looking for obvious findings:
 - Non-infectious cause of findings like fracture
 - Interpret with caution since pathologic fracture in setting of infection is possible
 - Infectious findings: periosteal reaction, lytic lesion
 - **A NORMAL XRAY DOES NOT RULE OUT OSTEOMYELITIS!!!!**
 - Need about 50% demineralization to see lytic lesions
 - Usually takes a couple of weeks for this to occur
 - Periosteal reaction usually not seen until 10-20 days after onset of symptoms

MRI For Diagnosing Pediatric MSK Infection

- Modality of choice for osteo and myositis
 - Marrow edema
 - Abscess
 - Sinus tract
 - Muscle inflammation
 - Synovial inflammation, but not the modality of choice for septic arthritis
- With and without contrast
- Information that helps determine if source control is needed

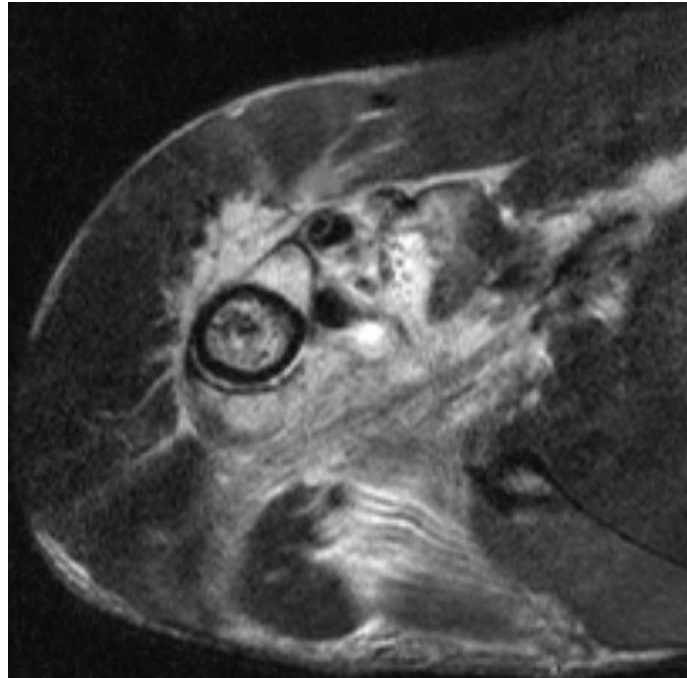
Other Imaging Options

- CT scan: similar sensitivity as MRI, but involves a lot of radiation
 - Useful for detecting a sequestrum
- Three phase bone scan
 - Radiolabeled tracer
 - Fallen out of favor since not as sensitive and can't see anatomical detail that may be needed for surgical intervention



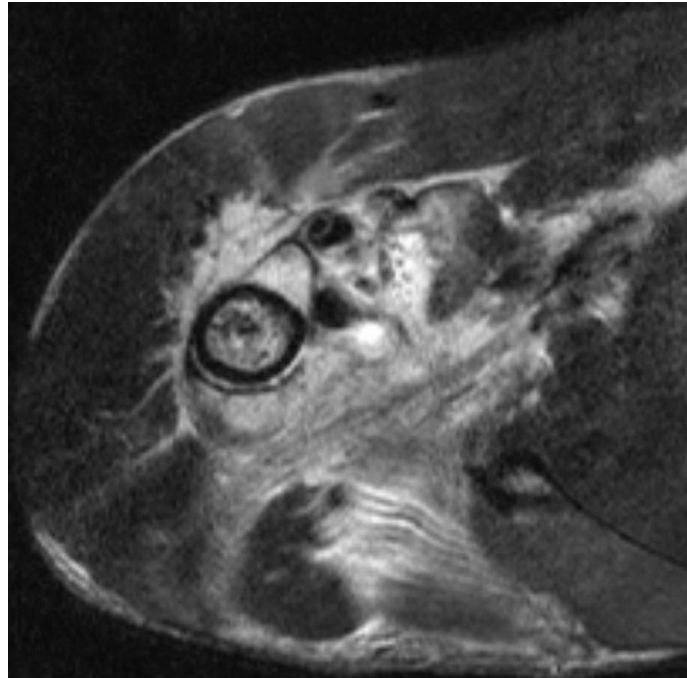
Back To Our 15 y/o Boy With Fever, MSK Pain

- Cough, congestion, lung exam improved
- Red flags
 - Fever, MSK pain/exam tenderness worse
 - WBC 21K (neutrophil predominant)
 - CRP 30mg/dl (normal <0.5mg/dl)



Back To Our 15 y/o Boy With Fever, MSK Pain

- I&D grew fusobacterium
- Improved after surgery and antibiotics and regained full function



MSK Infection: What's The Hurry?

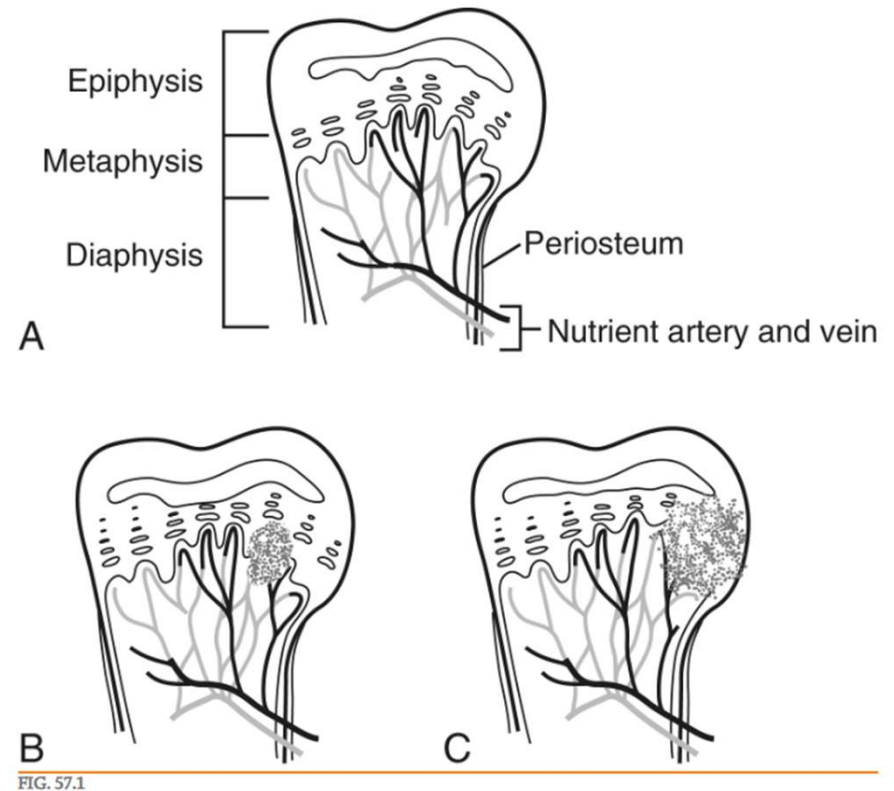
- 12 y/o girl, previously healthy
- Walking in the woods, trips on a root and twists her ankle, limps for an hour or so and then fine
- 2 days later has fever, and new swelling/erythema of the ankle
- MRI shows osteo of the distal fibula
- Gets started on IV antibiotics right away
- Within hours developed sepsis, ARDS requiring oscillator vent for several days, anasarca and was bacteremic for many days despite I&D and appropriate antibiotic therapy
- Blood and bone cultures grew MSSA

Acute Hematogenous Musculoskeletal Infection

- Most common cause of osteo, septic arthritis and bacterial myositis in Children
 - Usually caused by the organisms that cause bacteremia
 - Staph aureus, staph aureus, staph aureus
 - Strep pneumo, Group A strep
 - Rarer causes: salmonella, fusobacterium, etc
- Minor injury may play a role
 - Myositis rabbit model
 - Recall bias

Acute Hematogenous Osteomyelitis

- Usually idiopathic
- Young children
 - Periosteum not as adherent to the bone
 - More periosteal lifting
 - More rupture into adjacent soft tissue
 - More likely to cross the physis and enter the joint
- Older children
 - More likely to stay localized
 - Shoulder and hip within the capsule and can rupture into the joint



Non Hematogenous Causes

- Direct spread from local infection
 - Sinus infection and Pott's puffy tumor
 - Ear infection and temporal bone osteo
- Invasive infection from broken barriers
 - Open fracture
 - Surgical hardware
 - Surgical site infections
 - Chronic foot ulcer leading to osteo in patients with myelomeningocele

Osteomyelitis in Children: Other Considerations

- Acute vs subacute vs chronic
 - Acute: onset within days, more symptoms and more rapid progression
 - Subacute: longer onset, fewer symptoms
 - Chronic: many weeks onset/progression; usually minimally symptomatic
- Organism type
 - Virulent pathogens
 - More indolent pathogens like TB or Cocci
- Single vs multifocal sites
 - Organism type vs underlying cause



Pyomyositis and Septic Arthritis

- Mostly hematogenous spread
 - Same organisms as osteo
 - Similar history, progression and red flags
- Subacute and chronic presentation possible for infectious arthritis
- Myositis can often be viral but is self limiting
 - Influenza B
 - Other viruses implicated
 - Acute vs post infectious

MSK Infection Diagnosis

- Labs that increase suspicion:
 - WBC, ESR, CRP, procalcitonin
 - >50k WBC in joint fluid
- Culture
 - Biopsy, joint fluid, abscess
 - Bacterial, AFB, fungal
 - Blood culture: most are hematogenous spread
 - You get surprises sometimes
- Next gen sequencing?
- Organism specific testing

MSK Infection Management

- Source control
 - Abscess
 - Joint: time is tissue
 - Synovial destruction can lead to permanent disability
 - Hip: risk of avascular necrosis
- Empiric antibiotic therapy
 - What organisms do you want to cover?
 - Are they going to try to die on me?
 - Antibigram
 - Staph aureus
 - Cefazolin vs vanc vs clinda?

MSK Infection Treatment

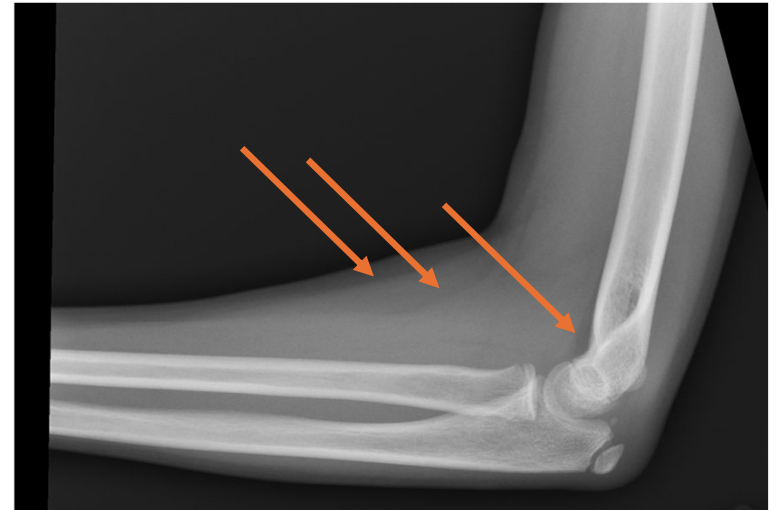
- Oral vs IV
 - Acute: usually start with IV and switch to oral therapy for home
 - Try to rapidly decrease bacterial burden with IV therapy
 - PO
 - Ideally have an organism susceptible to an antibiotic with good bioavailability
 - Improved exam, resolved fever, negative blood cultures (x2?), improving CRP
 - Chronic: some start with oral therapy
- Length of therapy
 - IDSA guidelines
 - Acute hematogenous osteo in children: potentially as short as 3-4 weeks
 - Bacterial arthritis in children: potentially as short as 10-14 days
 - Follow exam
 - Myositis may hurt for a long while
 - Inflammatory markers?

Putting It All Together: 10 y/o Girl With Elbow Pain

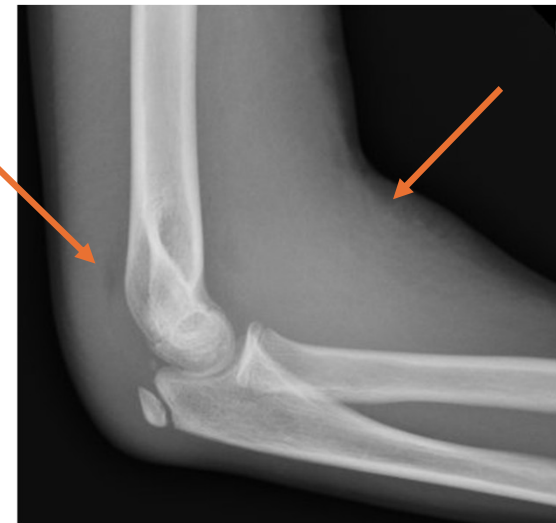
- Initial presentation
 - Healthy, no trauma, no fever, started hurting this morning
 - Mild tenderness on exam, o/w normal
 - Normal xray, goes home
- 3d later
 - More pain, new swelling, progressing over the last 24 hours
 - Warm, tender on exam
 - Afebrile
 - Exam and progression are suspicious so you get labs
 - Normal WBC
 - **Elevated CRP**
 - Get a blood culture since most are hematogenous spread
 - It's time for imaging

10 y/o With Elbow Pain

- New Xray abnormal
- Ortho consult
 - Joint tap for fluid
 - 143K WBC, GPC on stain
- Start empiric therapy for Staph aureus
 - Vancomycin due to joint involvement, rapidity of progression and extensive involvement on exam
- OR for joint washout
- Need additional imaging due to concern for extensive infection based on exam and xray



Initial Presentation: Normal fat pad, nice tissue lines

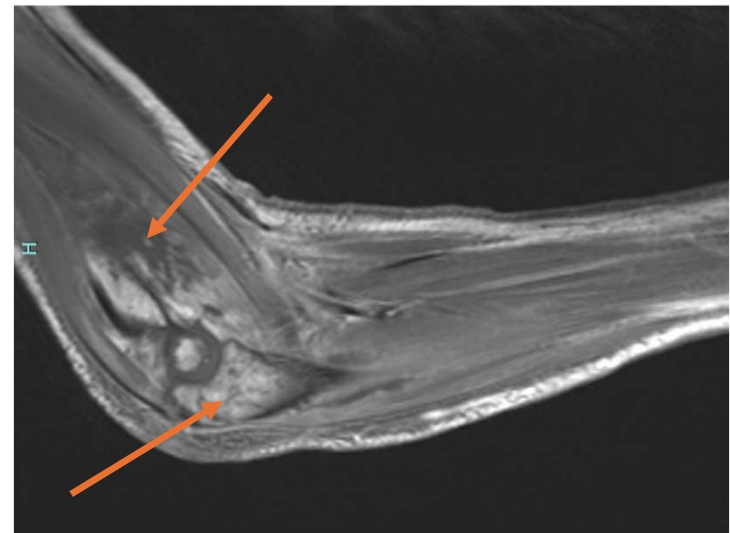


Now: new posterior fluid, loss of tissue lines

Difference Between Xray and MRI



Subperiosteal abscess



Marrow enhancement (osteomyelitis), myositis and abscess

10 y/o With Elbow Pain

- Imaging consistent with osteomyelitis, pyomyositis, septic arthritis, subperiosteal abscess and muscle abscess
- Blood and joint cultures growing MRSA
 - Covered by vanc
- Back to the OR for debridement of abscesses
- Bacteremic for 5 days
 - Echo negative, no additional joints involved
- Susceptible to clindamycin so stop vanc and start IV clinda
 - Since extensive infection and persistent bacteremia treat with 2 weeks of IV
- Exam improves, CRP improves
 - Switch to po and finish up a 6 week course
 - CRP and exam normal by end of therapy

10 y/o With Elbow Pain

- Pain, progression, exam consistent with infection
- Elevated CRP
- Normal WBC and afebrile
- Severe infection may not follow the textbook

17 y/o With Shin Swelling For 6 Weeks

- Slowly increased in size at first, but now stable for a few weeks
- No fever or pain
- Palpable induration on exam, but no tenderness, redness
- Normal WBC, CRP
- Lytic lesion with periosteal reaction on xray
- What is going on here?
 - Biopsy grew MSSA, did well on oral cephalexin



Chronic Osteomyelitis

- Symptoms usually present for weeks to months
 - May be minimal or absent
- Often afebrile with normal inflammatory markers
- Can have sequestrum
 - Makes it difficult to treat without surgical removal due to poor perfusion and antibiotic delivery
- Mechanism of infection similar to acute infection
 - Hematogenous spread
 - Direct inoculation
 - Broken barriers

Chronic Osteomyelitis

- Organisms depend on mechanism of infection
 - Can be similar to acute pathogens
 - Unclear why Staph aureus isn't more aggressive in this situation
 - Could be virulence mechanism vs host factor vs other unknown cause
 - Potential for more indolent, less pathogenic organisms
- No standardized treatment regimen
 - Hard to determine what is “long enough”
 - May not be able to follow resolution of pain, fever, inflammatory markers since they are often normal
 - Often can start with oral antibiotics

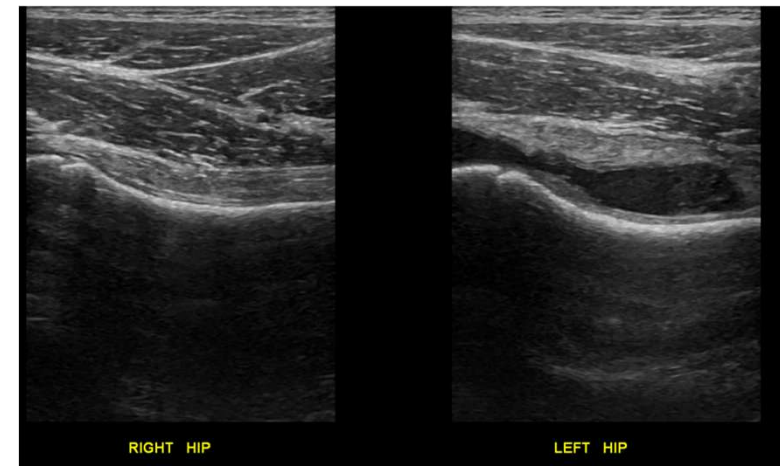
16 y/o With Open Fracture at Football Practice

- Repaired by ortho, but weeks later develops chronic draining wound
- Afebrile, normal inflammatory markers
 - Chronic osteo vs indolent organism (or both)
- Blood?! and OR cultures grew *Clostridium sporogenes*
- Continued trips to the OR with positive cultures until sequestrum discovered and debrided
- Did well with months of oral antibiotic therapy



13 y/o With Left Hip Pain

- 3 days of progressively worsening pain, now non weight bearing
- Some low grade fever
- Elevated CRP, normal WBC; blood cultures pending
- Holds left hip flexed and externally rotated
- What now?
 - u/s showed large effusion
 - Joint aspiration 67K WBC (84% neutrophils), nothing on gram stain
- I&D'd (cloudy fluid)
- Blood, fluid culture negative
- Started IV, changed to po cephalexin after I&D and improvement
- Normal CRP and exam at follow up
 - Completed 3 week course of abx
- Don't always get the answer, but all's well that ends well



Septic Arthritis Of The Hip

- Harder to distinguish since the joint is deeper than others
 - May not see redness/swelling
 - Hard to palpate for tenderness
 - Classically flexed/externally rotated
 - Time is tissue
- Kocher criteria (may help differentiating between septic **hip** vs transient synovitis)
 - 4 criteria: fever, non weight bearing, WBC >12k, ESR ≥40
 - All 4 met: 96%
 - 3 met: 93%
 - 2 met: 40% risk
 - 1 met: 3% risk
 - 0 met: 0.2% risk

2 y/o With Right Knee Pain

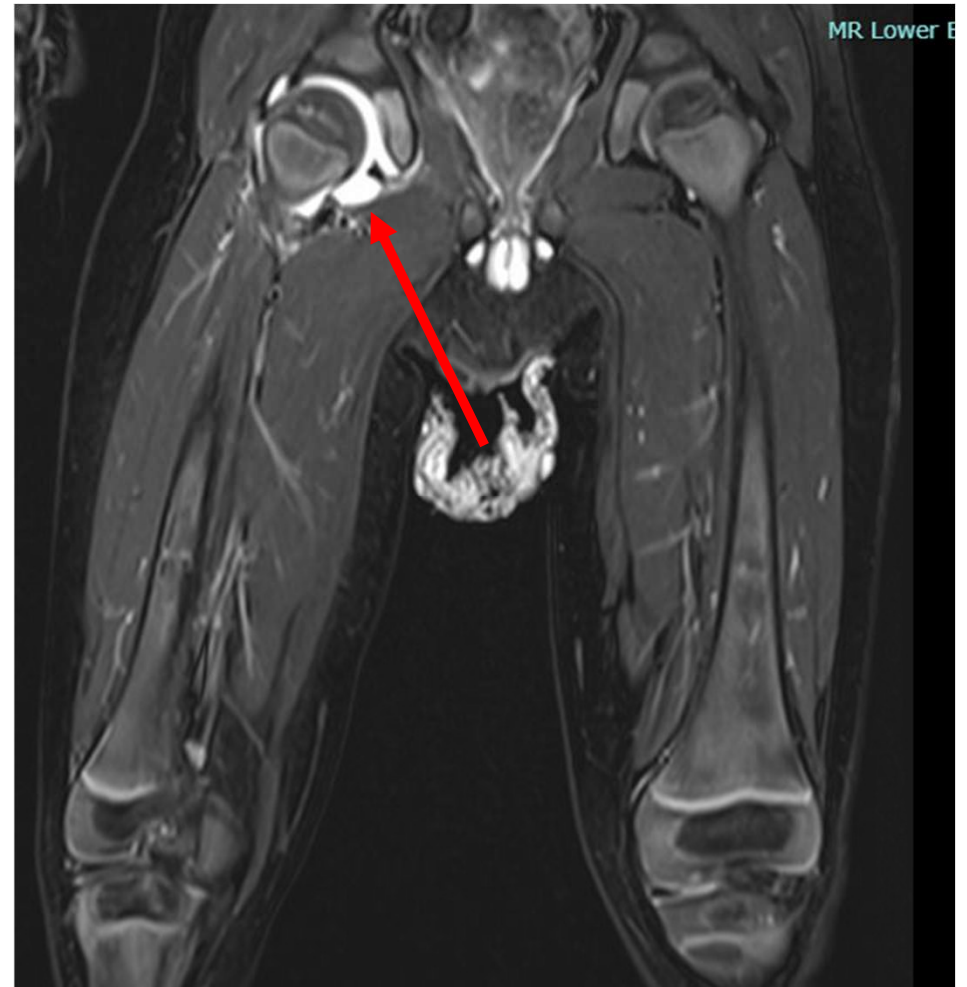
- 10d ago ST and runny nose, now resolved
- 5d ago falls and hits knee while hiking with family
- 2 days later **temp to 100.5**, persistent pain, knee tenderness, **decreased weight bearing**
 - Bruise on the knee, cries with passive ROM at knee and hip
 - Labs ESR 35, WBC 11
 - Afebrile in the ED
 - Kocher criteria: 2/4=40% risk hip infection
 - What now?
 - Xray negative
 - Unsuccessful knee tap, didn't try the hip
 - Admit and watch and he improves without empiric antibiotic therapy, goes home

2 y/o With Right Knee Pain

- 4 days later, getting worse
 - **Fever to 101**
 - **Non weight bearing**
 - **ESR 63**, WBC 11
 - Knee without swelling/tenderness
 - Holds hip flexed and cries with passive ROM
 - Kocher criteria now 3/4 = 93%

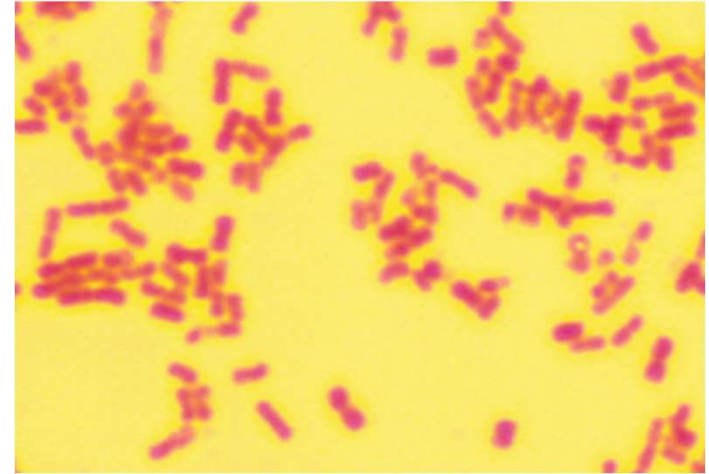
Our 2y/o with RLE pain

- MRI: big ol' hip effusion
 - Knee ok
 - No evidence of osteo
- Purulence in the OR, gram stain and cultures negative
 - Only 22k WBC in fluid analysis
- What do we end up getting?
 - *Kingella kingae* positive PCR



Kingella kingae

- Gram negative bacteria
 - Tends to colonize the oropharynx
- Joint infection (and rarely osteo) in toddlers
 - Initial protection from maternal antibody is lost
 - Often preceded by URI leading to invasive infection
 - Older children likely developed immunity from prior minor infection so don't usually get septic arthritis/osteo
 - Mild infection is classic
- Susceptible to cephalosporins, trim/sulfa
- I generally cover for *Kingella* empirically in children under the age of 5
- Kocher often criteria don't apply well to *Kingella* infections but worked out in this case



Key Points

- Mild presentation: think mild/slowly progressive organisms
 - *Kingella*, *coccidioides*, etc
- If things aren't going in the right direction, re-evaluate
 - Some things take a while to declare themselves
- Not all septic arthritis has $>50k$ WBC in the fluid
- Hip infection can cause referred knee pain
- If you don't get the right tests, you may not get the right answer

Teenager With Leg Pain

- AML receiving chemotherapy, pancytopenic
- Thigh pain started yesterday, initially mild
 - Today has rapidly progressed in size, with purpura and severe pain
 - Exquisitely tender on exam
- What is this and what do you do?
 - Necrotizing fasciitis, emergent surgery
 - Unfortunately passed away in the OR
 - Blood culture grew *Clostridium perfringens*



Necrotizing Soft Tissue Infection

- Classic description of Group A Strep after chickenpox in children
- Can have other organisms and can be polymicrobial
 - Staph aureus, gram negatives, anaerobes
- May have blistering and or bruising
- May see gas production on xray/CT/MRI
 - But really don't want to be wasting your time on imaging
 - Normal imaging does NOT rule out necrotizing infection
- Pain out of proportion to visible area affected
- Time is tissue
 - Needs emergent, wide debridement
 - False alarms are OK!

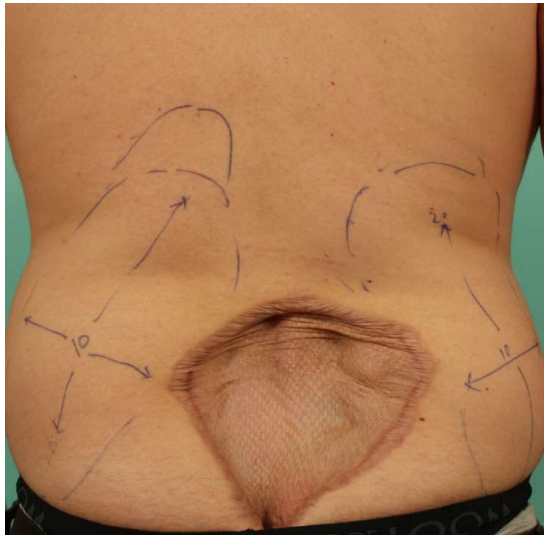
A Case With a Better Ending

- 16 y/o with sacral pain, pustule
 - MRI shows abscess
 - Develops fever, vomiting, rapid progression of pain and erythema
 - Severe pain out of proportion to exam findings
 - Taken to the OR, cultures grow GAS and prevotella





1 week post op



1 year later



1 y/o With Hand and Leg Pain

- Low grade fever for a couple of weeks
- Cries when you touch his hand and not wanting to move his leg much
- Lytic lesions on Xrays
- Diagnosis?
 - Coccidioides
 - Spherules seen on I&D
 - Does well on long term fluconazole



Coccidioides MSK infection

- Chronic osteomyelitis
 - Can affect any bone
 - Often not the typical long bones seen in acute bacterial osteo
 - Vertebrae, skull, tibia, metatarsals, metacarpals most common
 - Often multifocal
- Arthritis
 - Reactive arthritis “Desert Rheumatism”
 - Symmetric, self limiting
 - Infectious arthritis from direct inoculation (thorn) or dissemination
 - Also tends to be more indolent
 - Synovial biopsy may be needed

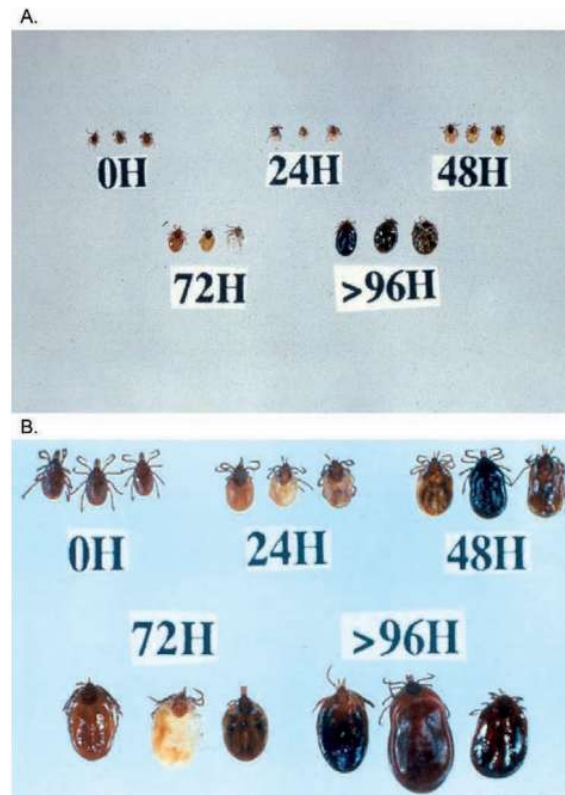
10 y/o With Right Knee Swelling After Visit to Iowa

- 2 weeks of pain and swelling, somewhat mild, somewhat progressive
 - Temp to 101 yesterday
- Was in Iowa in the summer, now it is December
- Knee is a bit swollen and somewhat warm, minimally tender and not particularly red
- ESR, CRP elevated
- Joint fluid 100K WBC with neutrophil predominance
- What bit him and what does he have?



Lyme Arthritis

- *Borrelia burgdorferi*
- Tick needs to feed for 36 hours to transmit
- We don't have lyme in AZ
- Many don't remember the rash or tick
- Arthritis shows up months later
 - Often indolent progression
- Serology very sensitive for arthritis
- Responds well to antibiotics



Reported cases of Lyme disease, 2023



Erythema Migrans

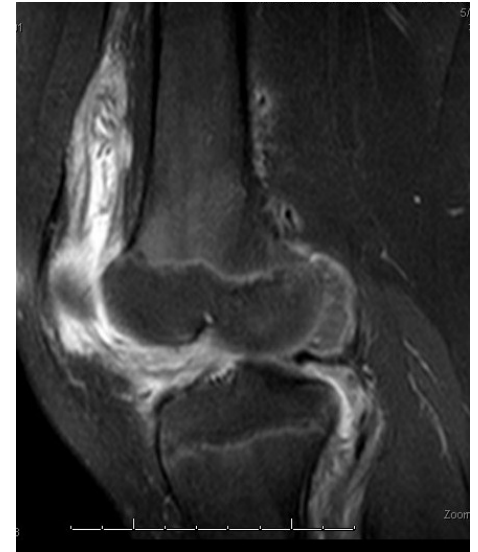


More Fun Cases

- 12 y/o with 4 months of knee pain and swelling
 - Slowly progressed to grapefruit size during that time
 - No fever, but has night sweats, limps a little bit
 - No other symptoms associated with this
- Knee with mild increased warmth, minimally tender, size of a grapefruit. Somewhat limits ROM
 - ESR a bit high, normal WBC and CRP
- Born in China, has been in the US for a decade
- No sick family members or contacts

12 y/o With Right Knee Pain

- MRI shows effusion, synovial enhancement of debris
- Knee joint fluid 7k WBC (lymphocyte predominant)
 - Initial stains/cultures negative
- PPD >>20mm induration
- Synovial biopsy grew *Mycobacterium tuberculosis*
- CXR neg
- Responded well to antibiotic therapy
 - Normal exam at 6 months
- Father and sister had latent TB (TB infection)
 - Treated to prevent reactivation (TB disease)
 - No known contacts with active infection in the past



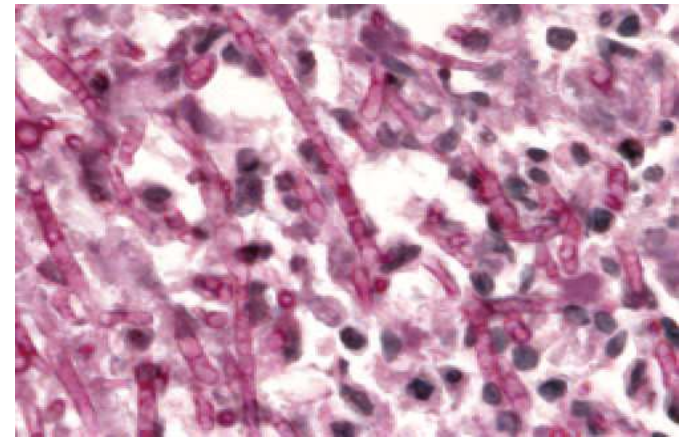
1 month Rx

6 y/o Foot vs Garden Spade

- Punctured his foot through his shoe while gardening in AL 3 weeks ago
 - Progressive redness, swelling, pain
 - 1 day of fever
- Exam: red, warm and tender dorsum of the foot
- Normal WBC, elevated ESR, normal CRP
 - Blood culture negative
- Soft tissue swelling on xray
- Purulence in OR and small erosion of the navicular bone
- Some initial improvement on empiric antibiotics (vanc and ceftaz)

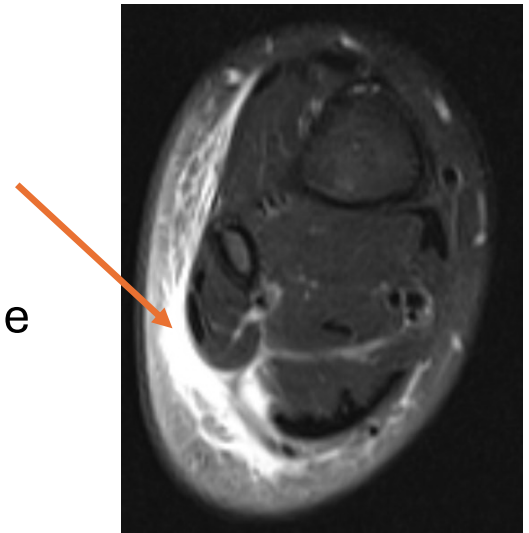
6 y/o Foot Osteo Due To Garden Spade Injury

- Worsening swelling, pain, drainage
- Back to the OR
- Mold starts growing on culture
 - Identified as *Scedosporium apiospermum*
- Treated with voriconazole
 - Did well after multiple debridements and months of antifungal therapy
- Osteo can come from direct inoculation
 - Wide range of organisms depending on the exposure
 - I always ask for bacterial, AFB and fungal cultures



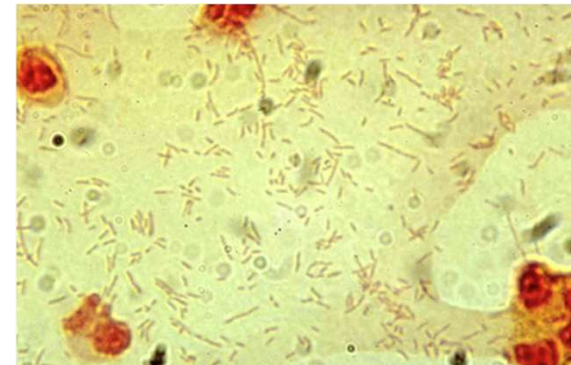
Frog Hunting

- 7 y/o wading in a pond and spears his ankle and a frog at the same time
- Next day has ankle pain, swelling and now is non weight bearing
 - Continues to progress over 2 days, now temp is 100
 - Few episodes of emesis
- Exam: swollen, red, tender ankle
- WBC and CRP elevated
- MRI showed inflammation and abscess near peroneal tendon
- Culture grows?
 - Aeromonas
 - Think water organisms (Aeromonas, Pseudomonas, Plesiomonas spp)



8-Month-Old With Left Elbow Swelling

- Unimmunized
- 3 days of fever, fussiness
- Red spot on elbow yesterday, now increased size and tenderness
- Exam: holds arm in flexion with erythema, tenderness and swelling of the left elbow. Cries with passive ROM
- Elevated WBC, ESR and CRP
- Joint aspirate 324K WBC (almost all neutrophils)
- What might you see on the gram stain?
 - GPC in clusters, GPC in chains?
 - Nope, this one has gram negative coccobacilli (can look like rods)
 - HiB
- Don't forget vaccine preventable illnesses



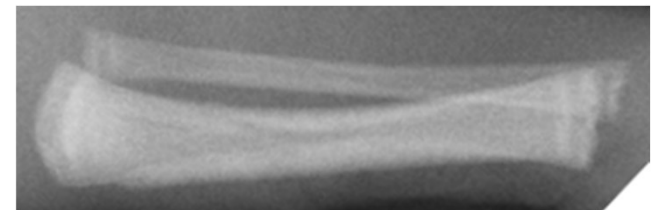
3-Week-Old That Won't Move His Legs

- Mom had prenatal care, negative prenatal labs at 1st visit
- Baby had normal exam at birth and discharged home with mom
- Baby recently had Flu A and cradle cap, noted elevated LFTs at the time
 - Now has enlarging erosive scalp lesion
 - Cries when you touch his arms and legs and doesn't like to move them
 - Afebrile
- Mom has new skin lesions
- What does the baby have?



Congenital Syphilis

- Both Mom and Baby's RPR were positive at presentation
- Both did well with penicillin treatment
- Can get osteitis and pseudoparalysis with congenital infection
- AZ is #4 in the nation for congenital infection
- Need maternal syphilis testing at entry to care, 28-32 weeks and at delivery
 - 50% tested negative earlier in pregnancy



Conclusion

- Take MSK symptoms seriously
 - Especially if fever, point tenderness, rapid progression and/or elevated inflammatory markers present
 - If in doubt get help and/or more information
 - Ortho, ID, surgery, etc
 - Additional imaging (MRI, etc)
- Most turn out well eventually
- Some can recur
 - Staph aureus tends to recur within weeks to months, but sometimes takes years
 - Keep an eye out for cocci

References

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