CT Guided Core Needle Bone Biopsy for Non-Vertebral Osteomyelitis: is it Necessary?

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Disclosure statement

None of the authors have conflicts of interest or relevant financial relationships to disclose.

Target audience

- Seasoned and training musculoskeletal radiologists.
- Physicians involved in the care of osteomyelitis patients.
Introduction

- Osteomyelitis is inflammation of the bone marrow which results from infection.

- It can progress to osteonecrosis, bone destruction, and septic arthritis.

- Osteomyelitis is an important cause of permanent disability worldwide.
  - Bimodal age distribution with incidence peaking in children under 5-years-old and adults over 50-years-old.
Introduction

- **Etiology:**
  - **Hematogenous spread**
    - Predominant etiology of infection in children.
    - Less common in adults, however usually leads to vertebral osteomyelitis when it occurs.
  
  - **Contiguous spread**
    - Infection originating from soft tissues and joints.
    - Usually coincides with vascular insufficiency, such as patients with diabetes mellitus or peripheral vascular disease.
    - Most commonly the lower extremities.
  
  - **Direct inoculation**
    - Direct seeding of organism into the bone usually from open fractures, surgery, or puncture wounds.
Introduction

- Imaging diagnosis
  - Radiography
    - Low sensitivity and specificity for detecting acute osteomyelitis.
    - Approximately 80% of patients within 1-2 weeks of infection have normal radiograph.
    - Bone marrow edema is the earliest pathological feature and NOT well visualized on radiography.
    - Useful as first-line imaging to exclude other differentials (i.e. fracture) and to assess progression from priors.
  - Nuclear Medicine
    - Sensitivity of a 3-phase bisphosphonate-linked technetium bone scan is greater than that of radiography for early osteomyelitis.
      - Diagnostic sensitivity of approximately 50-85%.
      - Low specificity of approximately 50% because nearly all bone disorders have increased uptake on a bone scan.
    - Can have increased specificity using other radionuclide agents (i.e. labeled WBC scan with sulfur colloid scan).
Introduction

- Imaging diagnosis
  - Ultrasound
    - Unreliable in the diagnosis of acute Osteomyelitis due to nonvisualized marrow.
    - However, useful in the diagnosis of fluid collections, periosteal involvement, soft-tissue abnormalities, and allows for possible intervention.
  
  - Computed Tomography
    - Useful method to detect early osseous erosions, foreign body, gas formation, or evaluating findings of chronic osteomyelitis (i.e. bone sequestrum).
    - Limited sensitivity compared to other modalities due to unreliable evaluation of osseous edema.

  - Magnetic Resonance Imaging
    - Diagnostic sensitivity for osteomyelitis has generally been reported at 90-100%.
    - Specificity can be limited by difficulty in distinguishing osteomyelitis from other causes of edema, such as acute neuropathic osteoarthropathy.
    - Positive and negative predictive values reported as high as 93% and 100%, respectively.
Introduction

Current diagnostic guidelines for non-vertebral osteomyelitis according to the ACR Appropriateness Criteria:
- Radiograph is the initial study of choice and is complementary to MRI.
- MRI should be performed with and without or without contrast for mapping devitalized areas preoperatively.
- Bone scan should be performed if MRI is contraindicated.

Diagnostic guidelines recommended by Infectious Disease Society of America.
- Wound culture from a deep location.
- Probe-to-bone test.
- Imaging (radiograph and MRI, bone scan if MRI contraindicated).
- Bone culture and histology.
Cameron or Greg, we need to complete this slide with the current diagnostic guidelines for non-vertebral Osteomyelitis diagnosis. *i.e. radiograph initially, MRI with contrast and/or biopsy and wound culture...* Whichever source you deem finite we should reference on the slide.

Donald von Borstel, 2/4/2018

ACR appropriateness criteria is only concerning imaging guidelines (I think precludes biopsies). Could you put another heading on this slide with a standard criteria for diagnostic workup past imaging; i.e. wound culture, biopsy culture, etc.

Donald von Borstel, 2/4/2018
Introduction

- Evidence based clinical practice guidelines for chronic wounds of the lower extremity, according to the American Society of Plastic Surgeons
  - Osteomyelitis evaluation
    - Imaging studies (plain radiograph, nuclear bone scan and/or MRI)
    - If imaging findings suggestive of osteomyelitis then consider histologic evaluation and bone biopsy culture.
The preferred diagnostic criterion for osteomyelitis is a positive bacterial culture from bone biopsy in the setting of bone necrosis.

Magnetic resonance imaging is as sensitive as and more specific than bone scintigraphy in the diagnosis of osteomyelitis.

Parenteral followed by oral antibiotic therapy is as effective as long-term parenteral therapy for the treatment of chronic osteomyelitis in adults.

A = consistent, good-quality patient-oriented evidence; B = inconsistent or limited-quality patient-oriented evidence; C = consensus, disease-oriented evidence, usual practice, expert opinion, or case series. For information about the SORT evidence rating system, go to http://www.aafp.org/afpsort.xml.

Hatzenbuehler, J. et. al. American Family Physician 2011

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<td>The preferred diagnostic criterion for osteomyelitis is a positive bacterial culture from bone biopsy in the setting of bone necrosis.</td>
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<td>Magnetic resonance imaging is as sensitive as and more specific than bone scintigraphy in the diagnosis of osteomyelitis.</td>
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<td>Parenteral followed by oral antibiotic therapy is as effective as long-term parenteral therapy for the treatment of chronic osteomyelitis in adults.</td>
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Table 1. Diagnostic Criteria for Chronic Osteomyelitis

- Imaging studies (e.g., plain radiography, magnetic resonance imaging, bone scintigraphy) demonstrating contiguous soft tissue infection or bony destruction
- Clinical signs
  - Exposed bone
  - Persistent sinus tract
  - Tissue necrosis overlying bone
  - Chronic wound overlying surgical hardware
  - Chronic wound overlying fracture
- Laboratory evaluation
  - Positive blood cultures
  - Elevated C-reactive protein level
  - Elevated erythrocyte sedimentation rate

NOTE: Items listed in order of decreasing diagnostic ability for osteomyelitis. If osteomyelitis is suspected, a bone biopsy with bacterial culture should be considered for definitive diagnosis.

Information from reference 17.
Purpose

- To evaluate the utility of bone biopsy in the diagnosis of non-vertebral osteomyelitis.

- To assess the effect of the bone biopsy in eliciting changes in subsequent clinical management.

- To evaluate if other diagnostic methods lead to similar clinical decision making.
Materials and Methods

- A retrospective review of 35 bone biopsies performed by a single institution for suspected non-vertebral osteomyelitis from 2013-2016.
- Data collected and analyzed from these cases included biopsy location, wound culture, bone culture and pathology results, preoperative MRI results, and antibiotic therapy prior to and after bone culture results.
- Selection criteria included non-vertebral cases of clinical osteomyelitis.
- Majority of osteomyelitis sites involved the foot or ankle (metatarsal, sesamoid, calcaneus, etc.), which constituted 25 of the 35 cases.
Materials and Methods

- Biopsy was performed by various radiologists within our institution using either a 17-gauge Percucut (Cook Medical, Bloomington, IN), 11-gauge Osteo-Site (Cook Medical, Bloomington, IN) or 11/18-gauge T-Lok (Argon Medical Device, Frisco, TX) biopsy needles.

- Biopsy specimens were sent for culture and/or pathology evaluations.

- Culture results were presented as negative or positive, which was used as the primary outcome for diagnostic yield.

- 9 of the 35 cases were excluded from analysis due to incomplete culture results or unknown use of antibiotic therapy prior to biopsy. A total of 26 cases were included in the final analysis.

- All statistical analysis performed with Microsoft Excel for Mac version 15.40.
Diagnostic yield of bone biopsies

- Diagnostic: 30%
- Non-diagnostic: 100%
Negative bone cultures were found to have very little effect on therapy decisions. A majority of cases with negative culture results continue antibiotic therapy with only one case terminating therapy completely. In the low number of cases with a positive bone culture, there was less than 25% overall change in therapy.

*Change in therapy includes antibiotic treatment termination, starting antibiotic therapy, or transitioning to different antibiotics.
A change in therapy occurred more often based on MRI diagnosis of osteomyelitis than with bone culture results. Also, 66% of the cases without a change in therapy were already being treated with antibiotics prior to the MRI.
Results

- Of the cases with MRI diagnosis of osteomyelitis, therapy change occurred in 7 cases (approximately 30%).

- Of the MRI positive cases which ended up having a change in therapy, 4 of them (over 50%) were started on antibiotic therapy after obtaining positive bone cultures and were not treated prior to MRI.

- Of the remaining patients with MRI diagnosis of osteomyelitis (approximately 70%), either no antibiotics were used or no changes in therapy were made after bone biopsy.

- MRI was performed in 23 of the 26 cases, all with MRI diagnosis of osteomyelitis.
Results

- Of the 26 cases we reviewed, eight (30.8%) were diagnostic of an organism on bone culture.
- Antibiotic coverage was changed in 6 of the 8 cases with a positive culture.
- Of the 8 cases with a positive bone culture, 6 had identical wound culture results.
- 50% of cases with positive bone culture results had a prior MRI performed.
- MR positive findings of osteomyelitis had a statistically significant association with antibiotic therapy (p=0.0004) versus no significance seen with bone culture positive results (p=0.428).
MR findings of osteomyelitis were seen in 23 of the 26 cases within our study, of which, approximately 17% had a positive bone culture.

- Our study suggests that bone culture is much less sensitive than MRI for the diagnosis of osteomyelitis.
- The low-yield of positive cultures in our study may have been skewed by pre-procedural antibiotic treatment.

Our study did show a statistical significance with positive MRI findings compared to positive culture results.

- This suggests a direct association of MRI evidence of osteomyelitis with treatment.

16 of the 23 patients with MRI findings of osteomyelitis had no changes in therapy after biopsy results. Meaning that 70% of those with MRI diagnosed osteomyelitis had no therapy change after subsequent biopsy.

- This suggests that clinical decision making (empiric therapy or non-treatment) has already been made before bone biopsies are performed and the procedure ultimately has little effect on management.
Discussion

- Results of this study showed that there was a low-yield (approximately 31%) of bone biopsy cultures.
  - This is consistent with previous studies showing negative cultures in 40-60% of cases. White LM, et al. Radiology 1995.

- Currently, the gold standard for the diagnosis of osteomyelitis is bone biopsy with a positive culture and histopathology showing osteonecrosis.

- Within our study, 15 of the 26 patients were started on empiric therapy prior to bone biopsy and two of these patients had a positive bone culture result.
  - 13 of 15 patients with pre-biopsy antibiotics had a negative bone culture result.
  - This might suggest that pre-biopsy antibiotics may have limited our diagnostic yield. However, pre-treatment likely does not affect diagnostic yield as significantly as historically thought. Wu JS. et al. AJR 2007.
Osteomyelitis is usually associated with either a concomitant soft tissue infection or wound; especially in the adult population.

Bone biopsy has the potential of seeding a non-infected bone from a regional soft tissue infection or wound flora. Also, false positive results could occur with contamination of the biopsy from the adjacent wound.

From our results, 75% of the positive culture cases had an identical wound culture.
- This brings into question whether the bacteria-specific diagnosis of osteomyelitis can be adequately performed by wound culture alone. Prior studies having indicated this could be possible. Malone M, et al. Diabetes Metab Res Rev 2013.

With our study showing a high sensitivity of MRI in the diagnosis of osteomyelitis and bacteria-specific diagnosis obtained by wound culture, this would suggest the ability to circumvent bone biopsy in some cases.
Discussion

- Limitations of our study are:
  - Small sample size.
  - Lack of standardized biopsy technique and performing radiologists.
  - Lack of long-term follow-up.
  - Single institution.
  - Retrospective study.
Summary

- MRI has proven to be an adequate means of confirming clinical diagnosis of osteomyelitis and is diagnostic for beginning antibiotic therapy.

- Percutaneous non-vertebral bone biopsy has demonstrated low clinical value in our study, with approximately 70% of MRI diagnosed osteomyelitis cases having no change in therapy after bone biopsy culture results.

- Also, approximately 75% of the bone biopsy positive cases had wound culture results yielding identical organisms.
  - This would suggest that treatment could potentially be started with MRI findings of osteomyelitis and the specific organism commonly identified by the wound culture.
Summary

- In most cases, bone biopsy does not change clinical decision making but merely confirms diagnosis based on wound culture or MRI findings.

- However, a small number of cases (approximately 23%) do have a change in therapy after bone biopsy results.
  - Therefore, if a bone biopsy and culture is necessary by the department standards; it should be taken into consideration that the result will only be clinically helpful in less than 1 out of 4 patients.

- Further study should be performed to investigate the long-term outcome of osteomyelitis diagnosed with bone biopsy as opposed to diagnosis with MRI and local wound culture alone.
References
