The Many Faces of Osteomyelitis

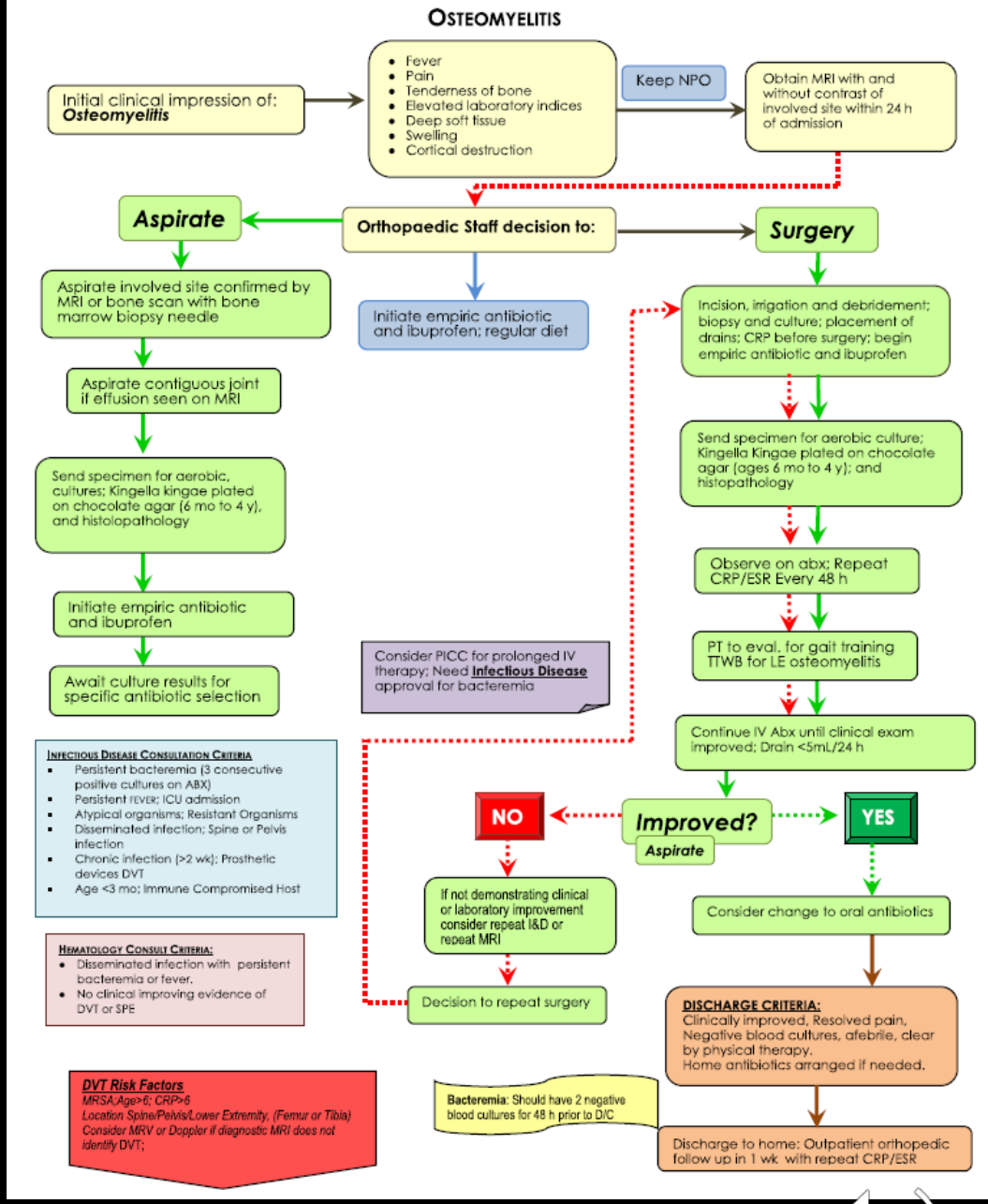
David A. Spiegel, M.D.
Childrens Hospital of Philadelphia
Associate Professor of Orthopaedic Surgery
University of Pennsylvania School of Medicine

1) Infection reduces average orthopaedic surgeons IQ by *50-80 points*





2) "Multidisciplinary and collaborative process"



Funk SL, Copley LAB. Ortho Clin North Am 2017;48:199-208.



"Many Faces"

3) Continuum defined by

- Host
- Pathogen
- Treatment
- Chronicity





Acute Hematogenous Osteomyelitis

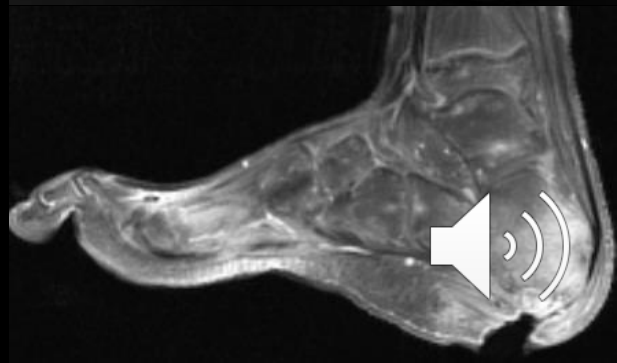


Neurologic or Vascular



Open fractures or Post-Surgical





- **Invaders**
  - **Bacteria**
  - Fungi
  - Mycobacteria
  - Parasites



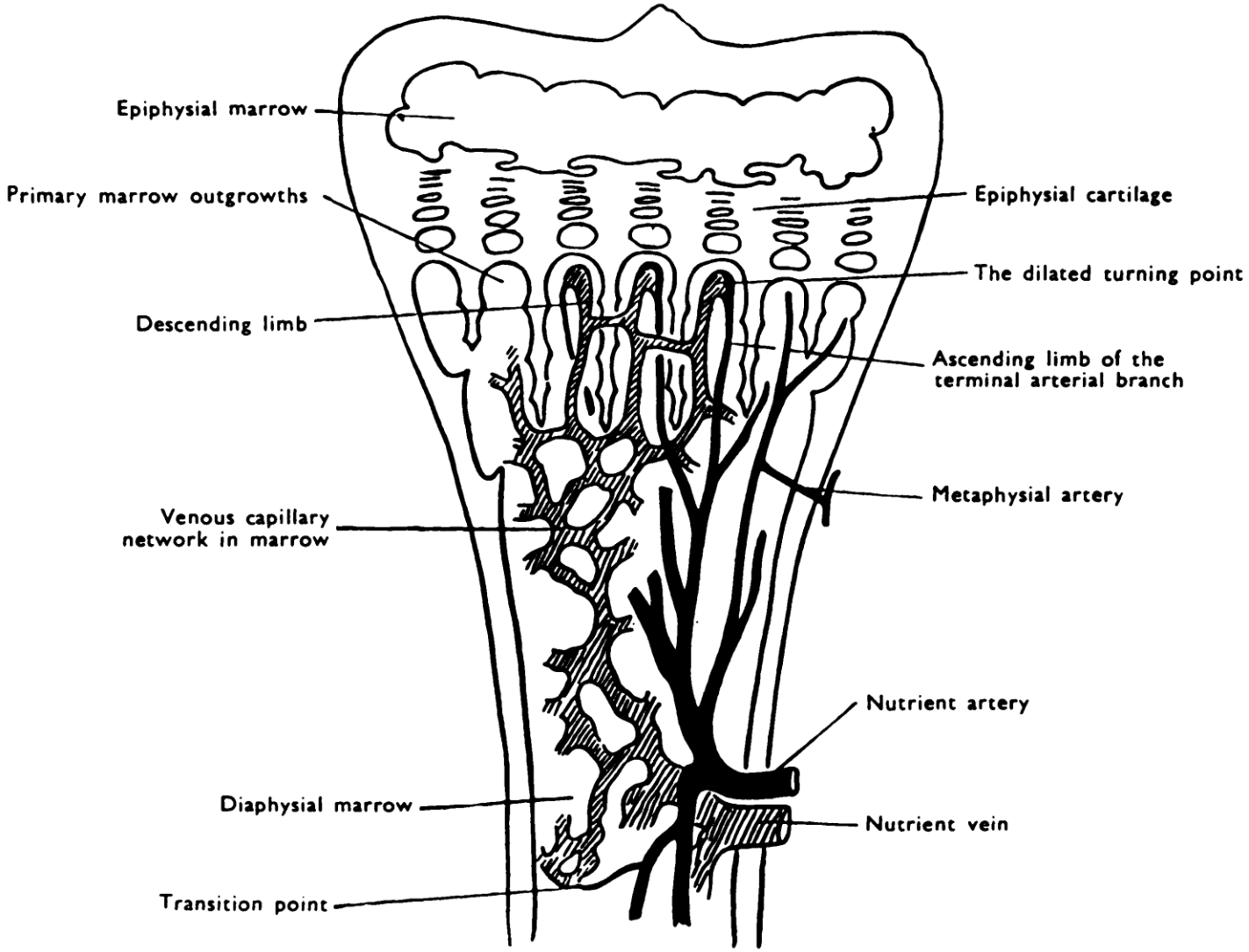


THE THREE TYPES OF ACUTE HAEMATOGENOUS OSTEOMYELITIS

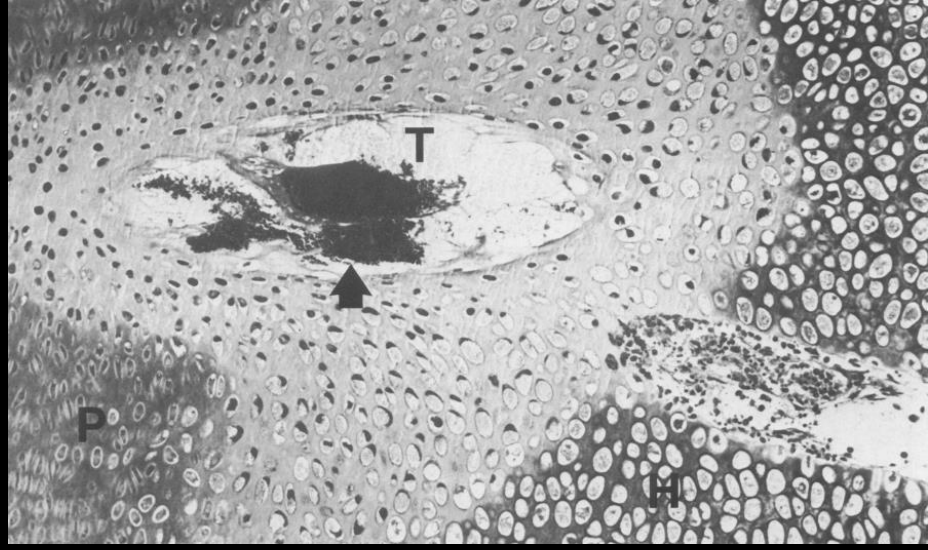
A Clinical and Vascular Study

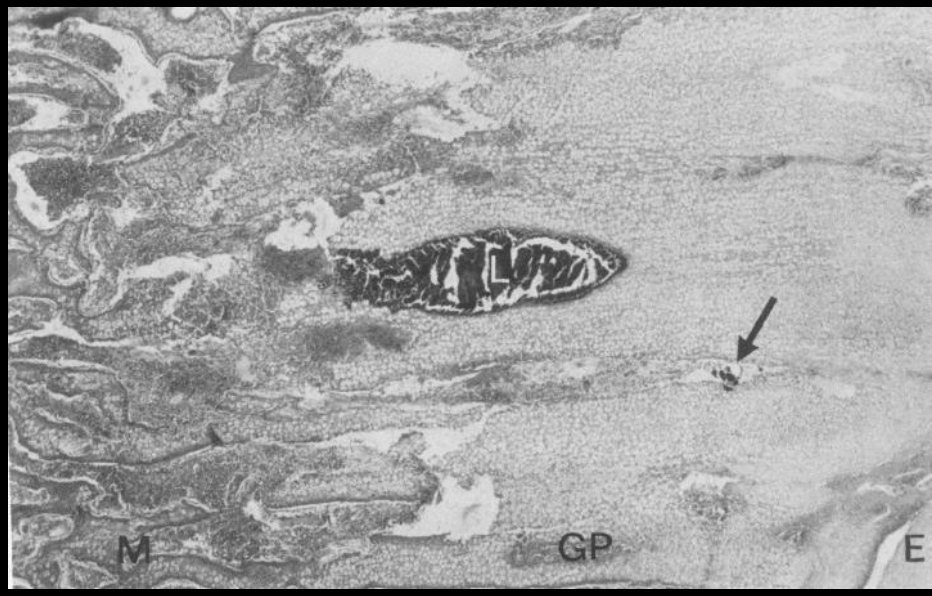
JBJS 1959;41B:671-680.

J. TRUETA, OXFORD, ENGLAND



- Terminal metaphyseal vessels are open-ended
- Bacteria attach to cartilage cells at junction of metaphysis and physis

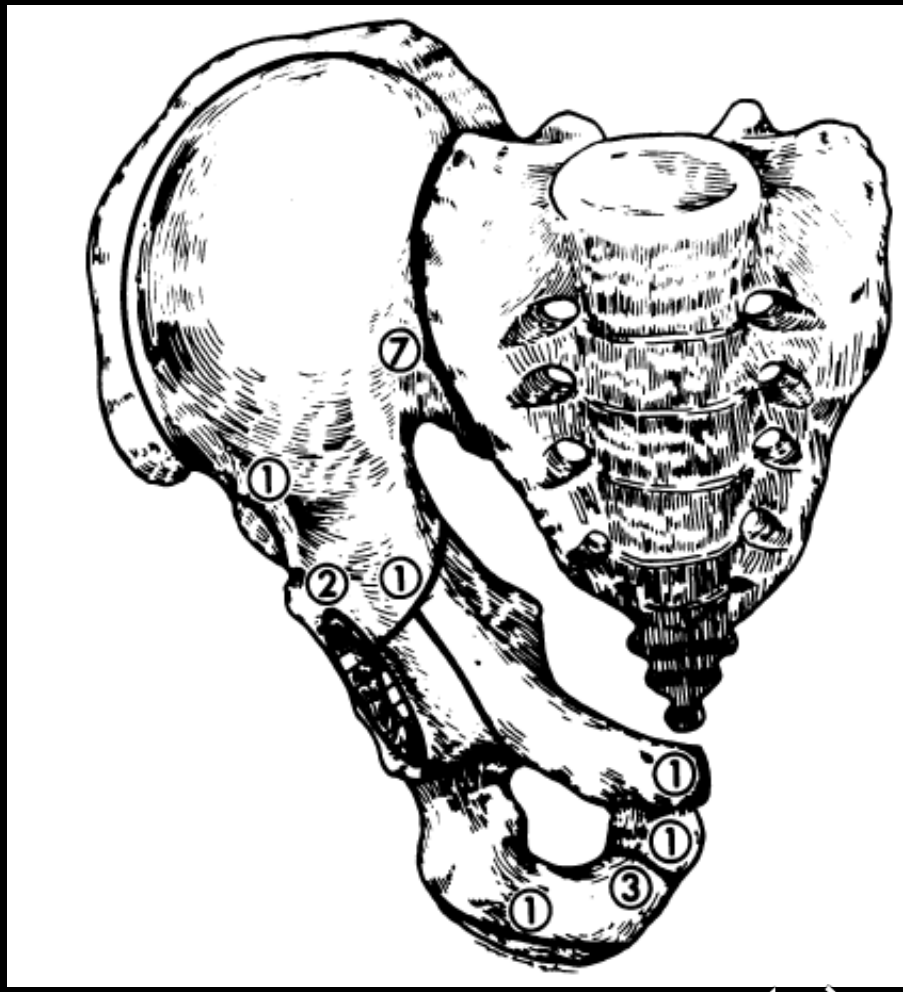




Emslie KR, Nade SML. Am J Path 1984;110:333-345.
Speers DJ, et al. Infect Immun 1985;49:443-446.

"Metaphyseal-Equivalent Locations"

- "Flat and irregular bones"
- Areas adjacent to cartilage
- 30% of AHO



Nixon GW. Am J Roentgenol 1978;130:123-129.



2) Pathophysiology:

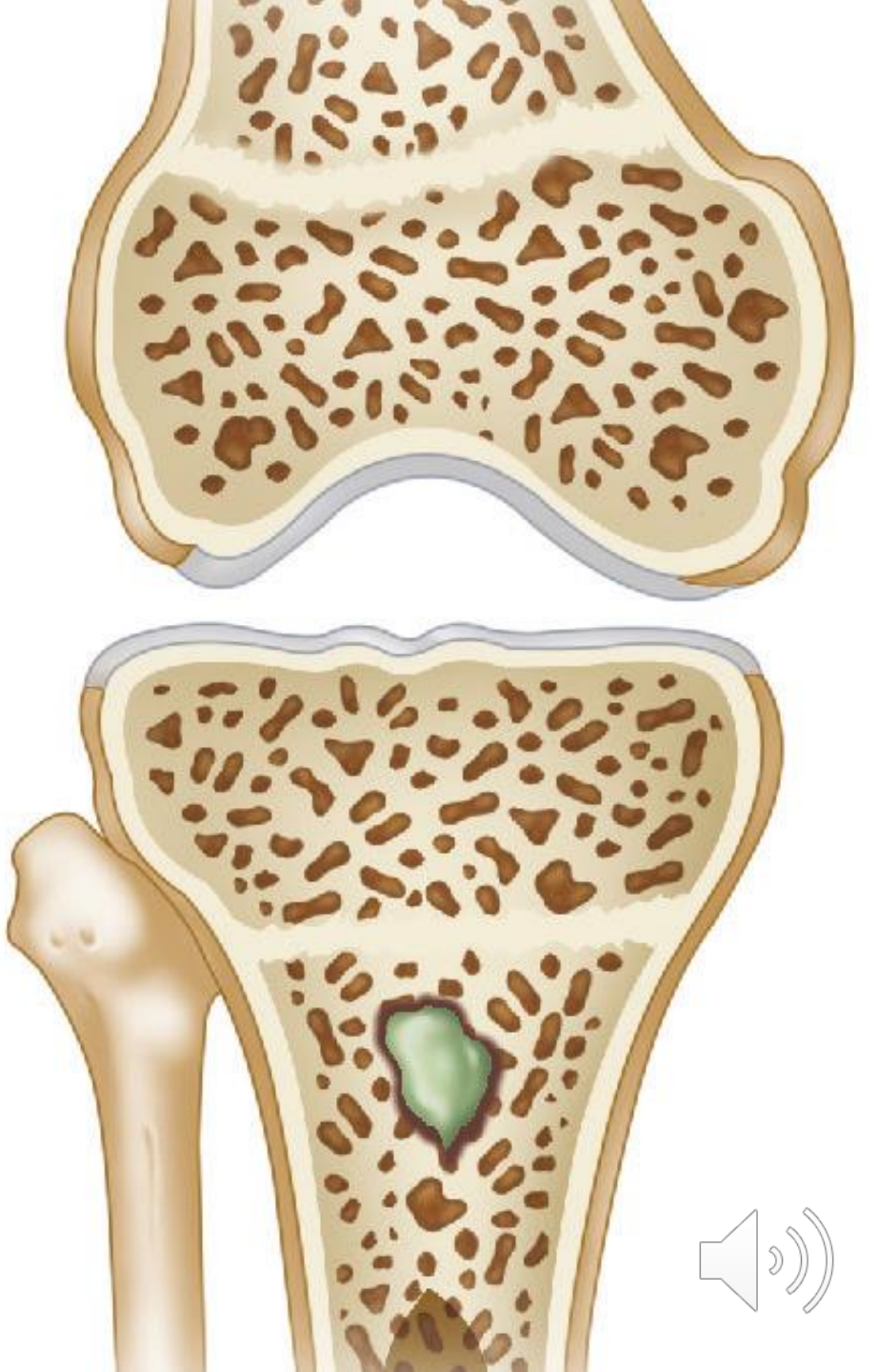
Contamination/colonization followed by manipulation of systemic inflammatory response

Colonization of metaphysis or "Equivalent"

Inflammatory response

Intraosseous abscess

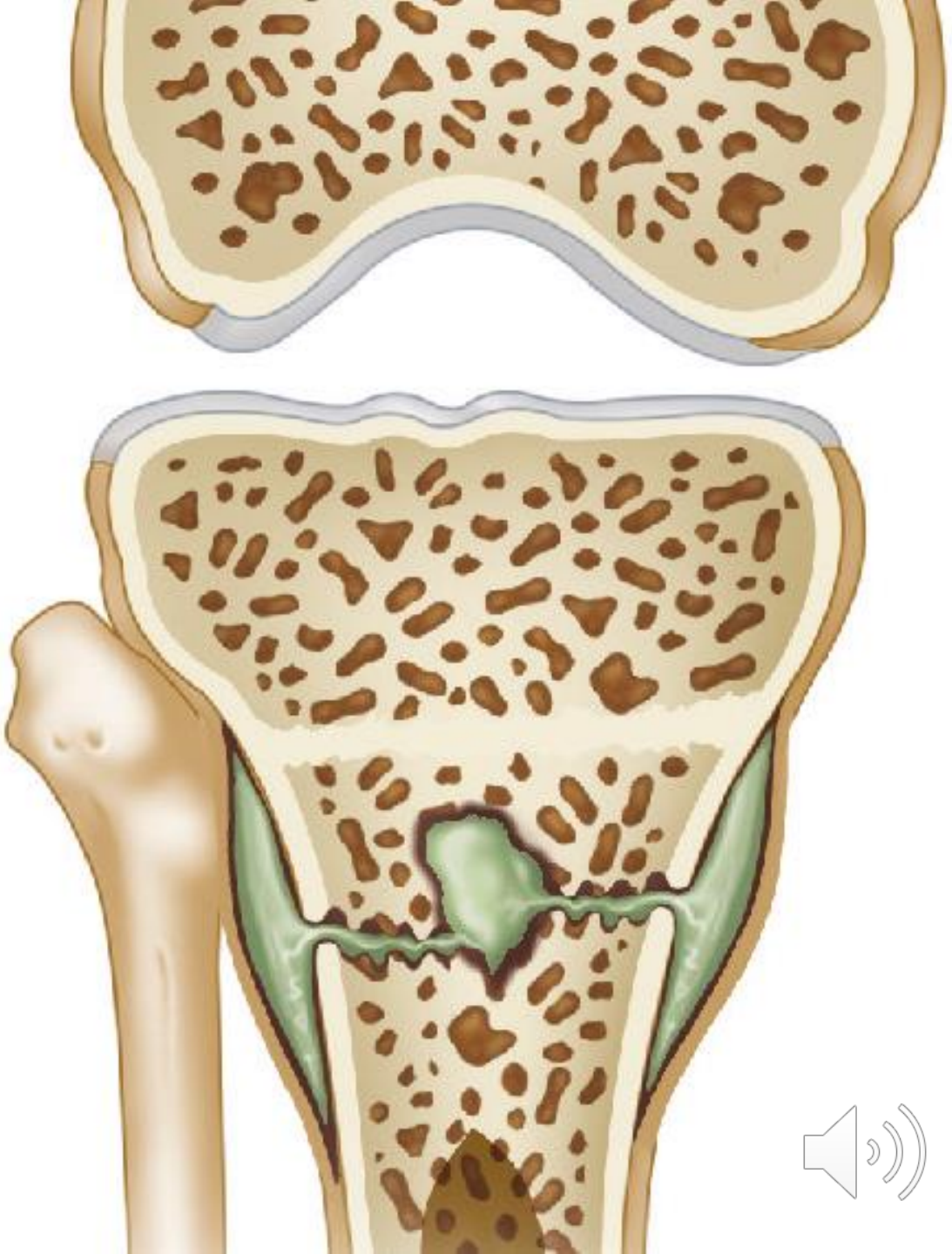
Gosselin RA, Spiegel DA, Folz M. Global Orthopaedics, Springer, 2014



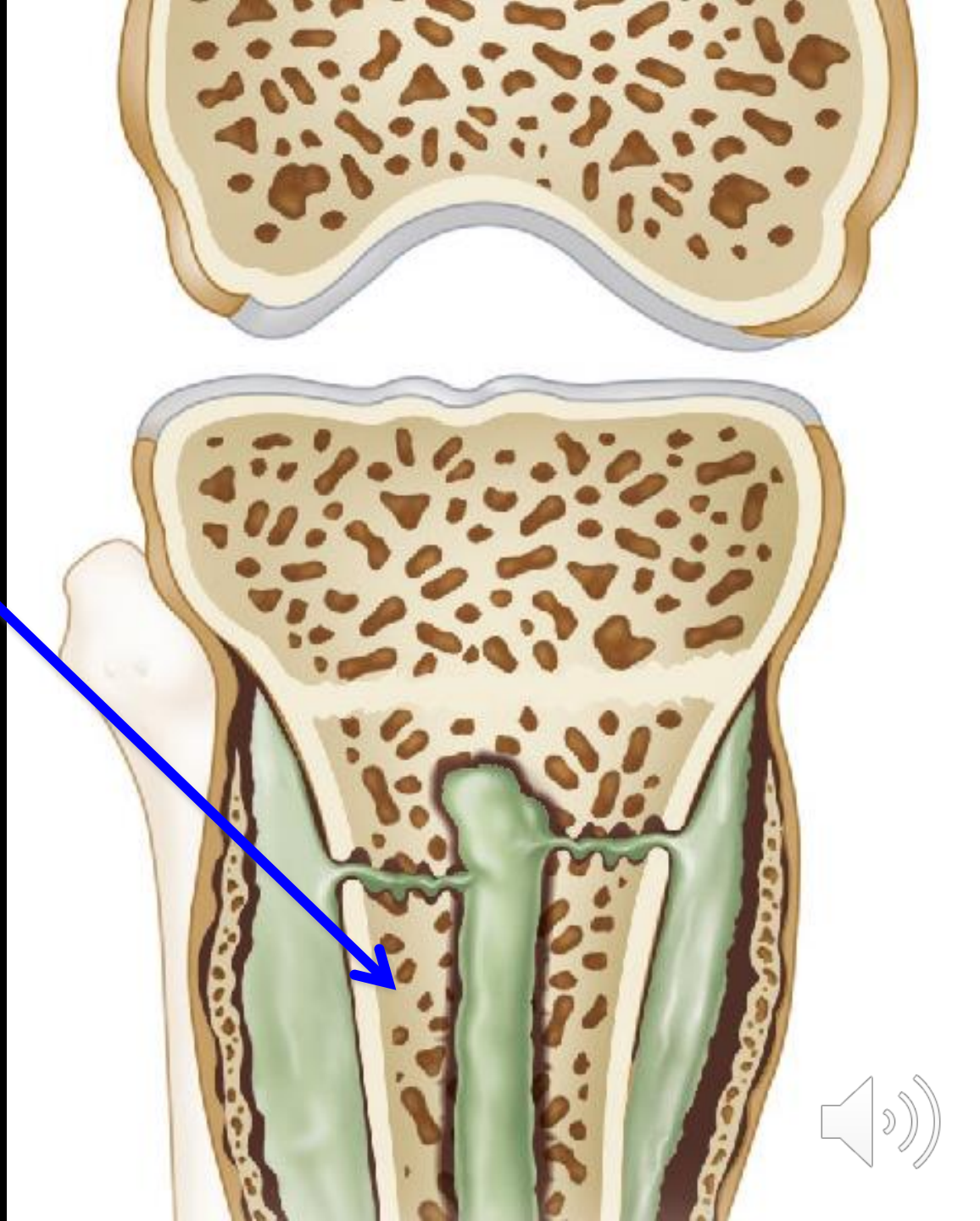
Subperiostial abscess

Bone resorption

Thrombosis, Ischemia, infarction

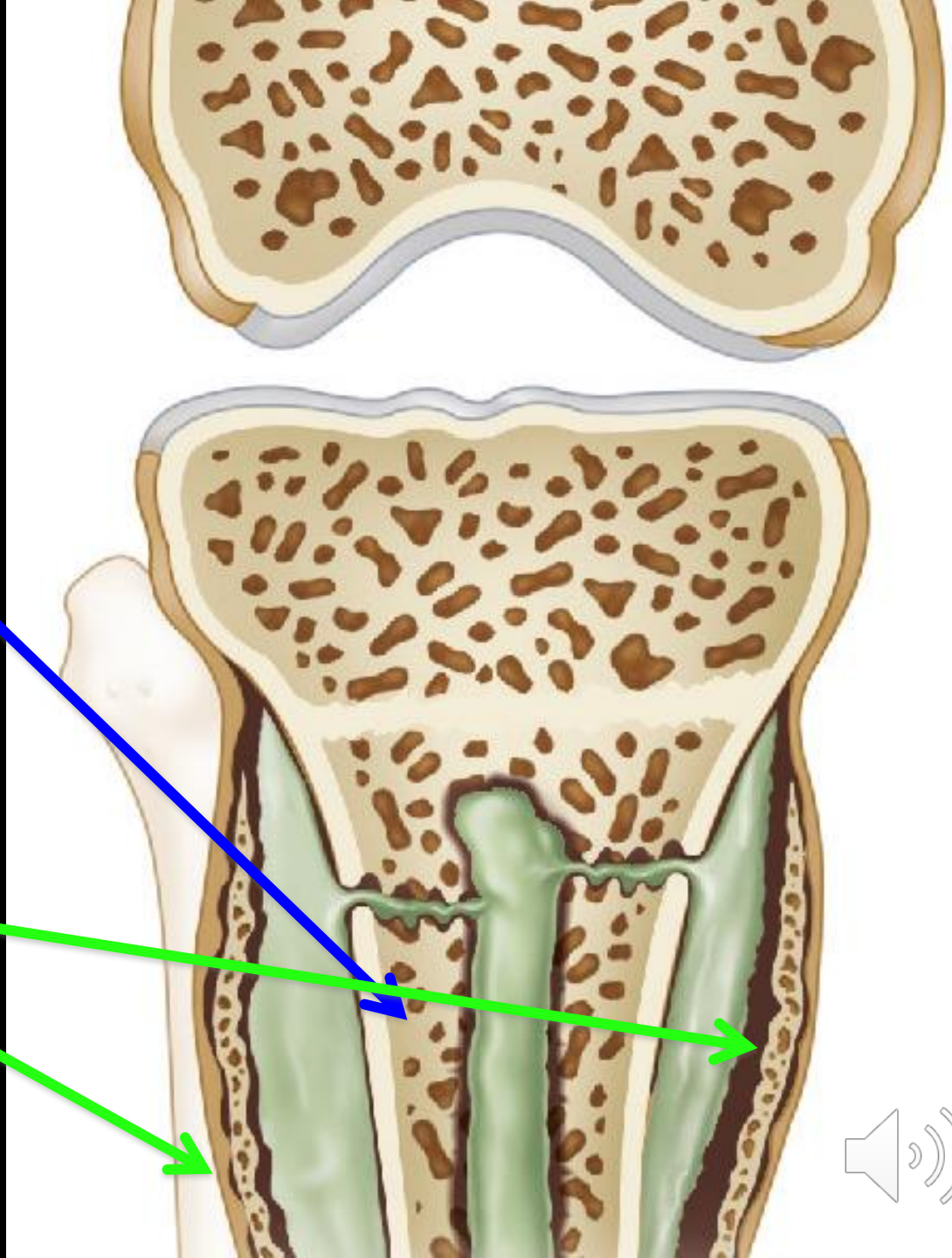


Sequestrae

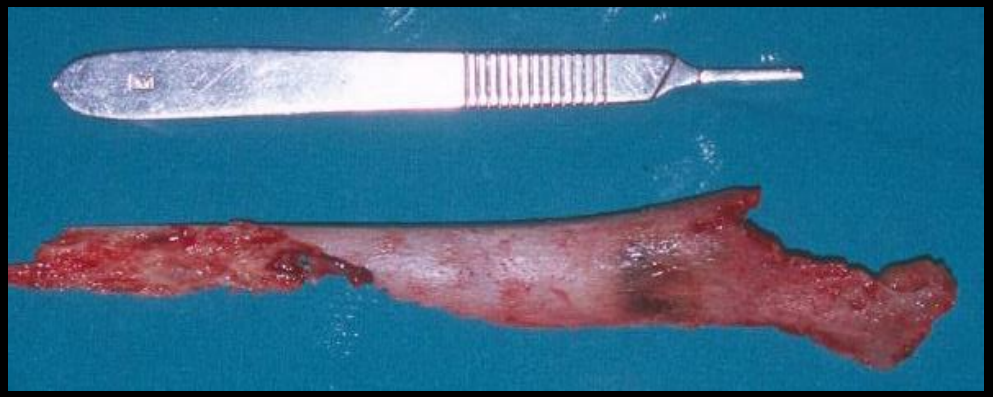


Sequestrae

Involucrum



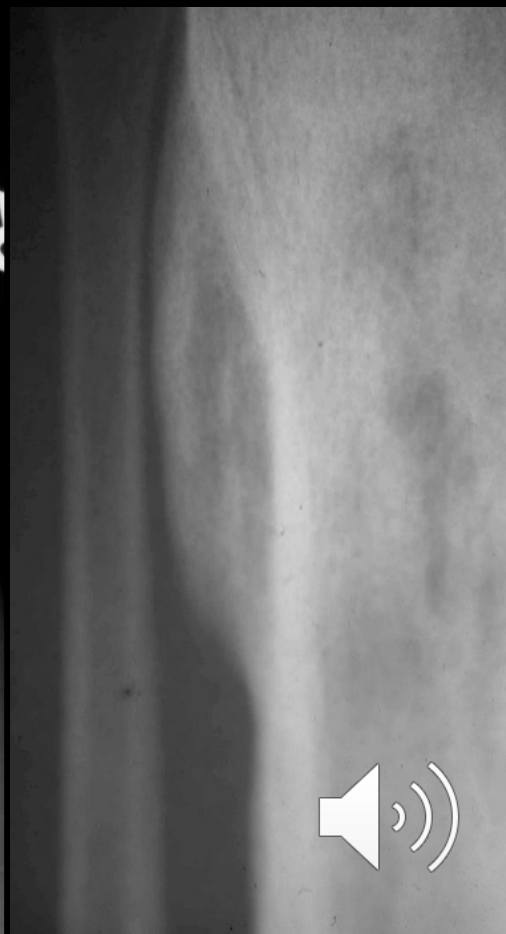
Sequestrum









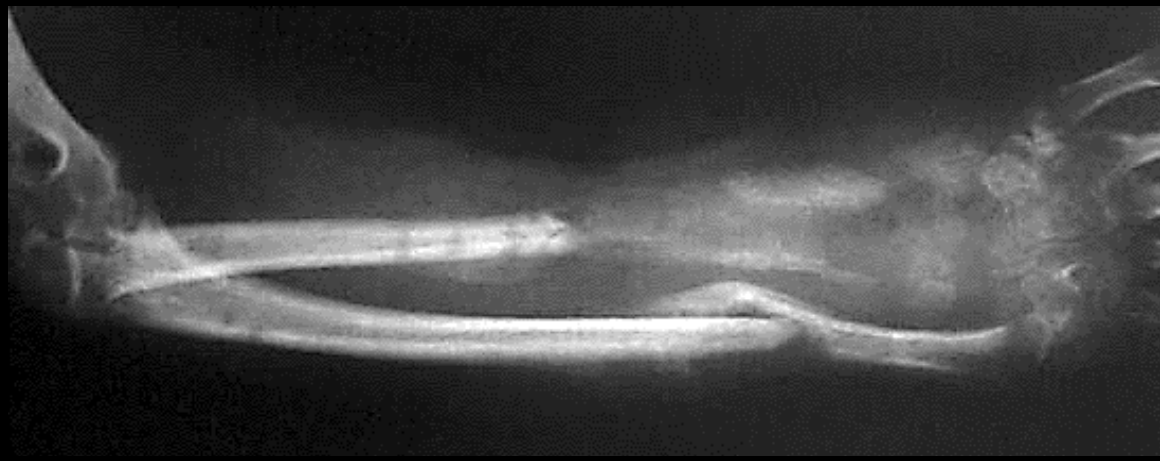









Involucrum

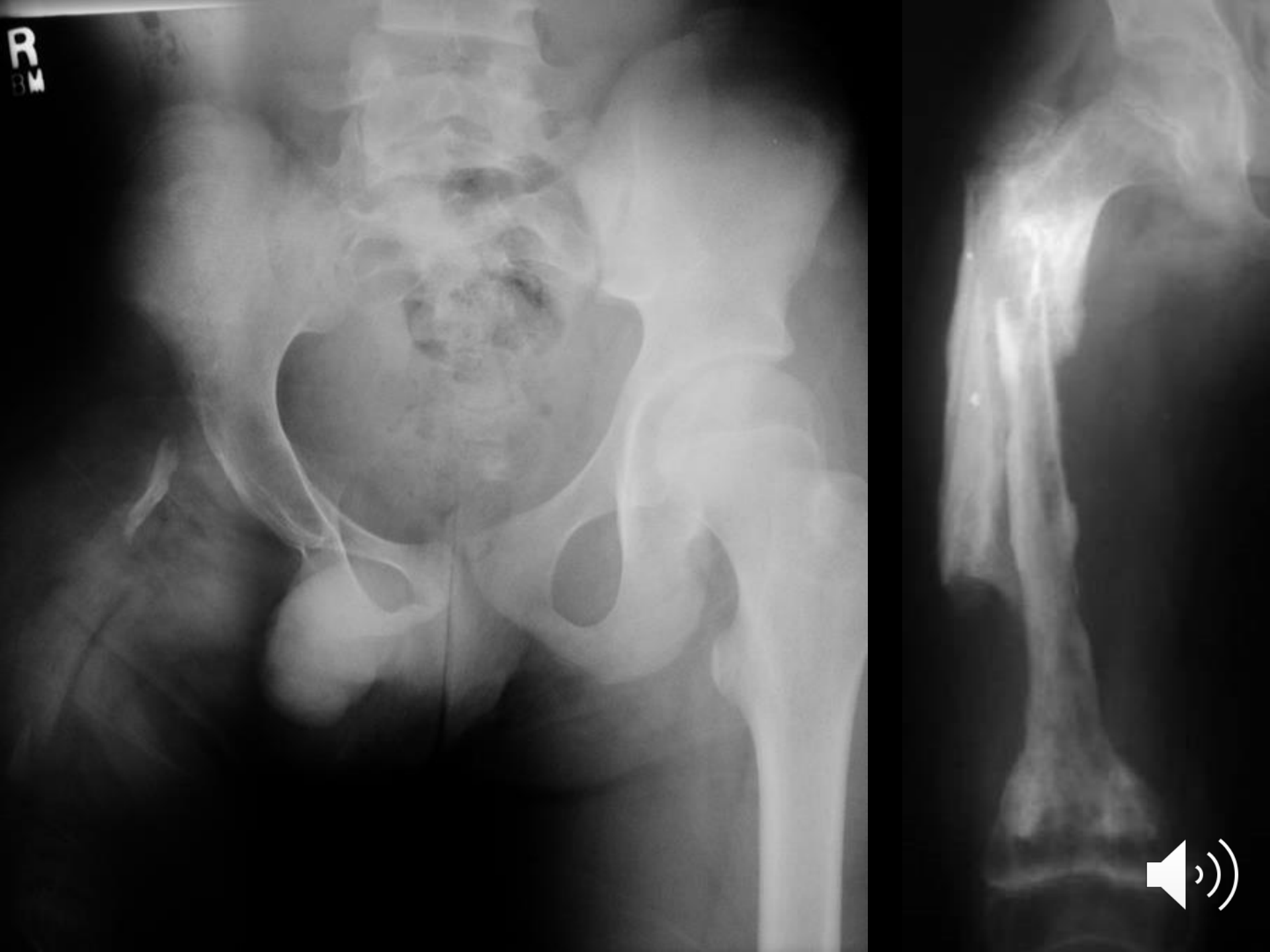


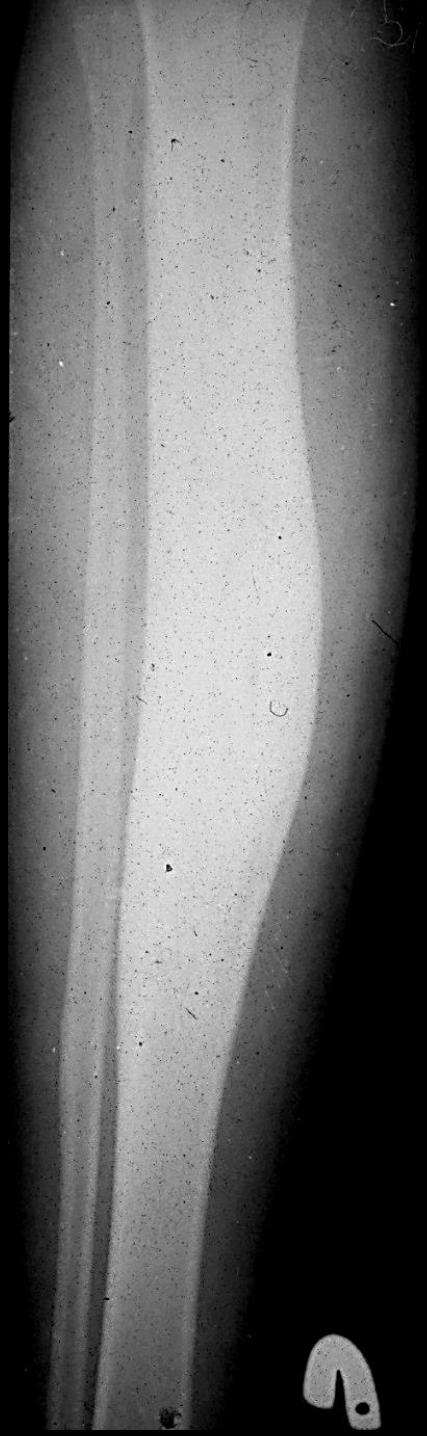


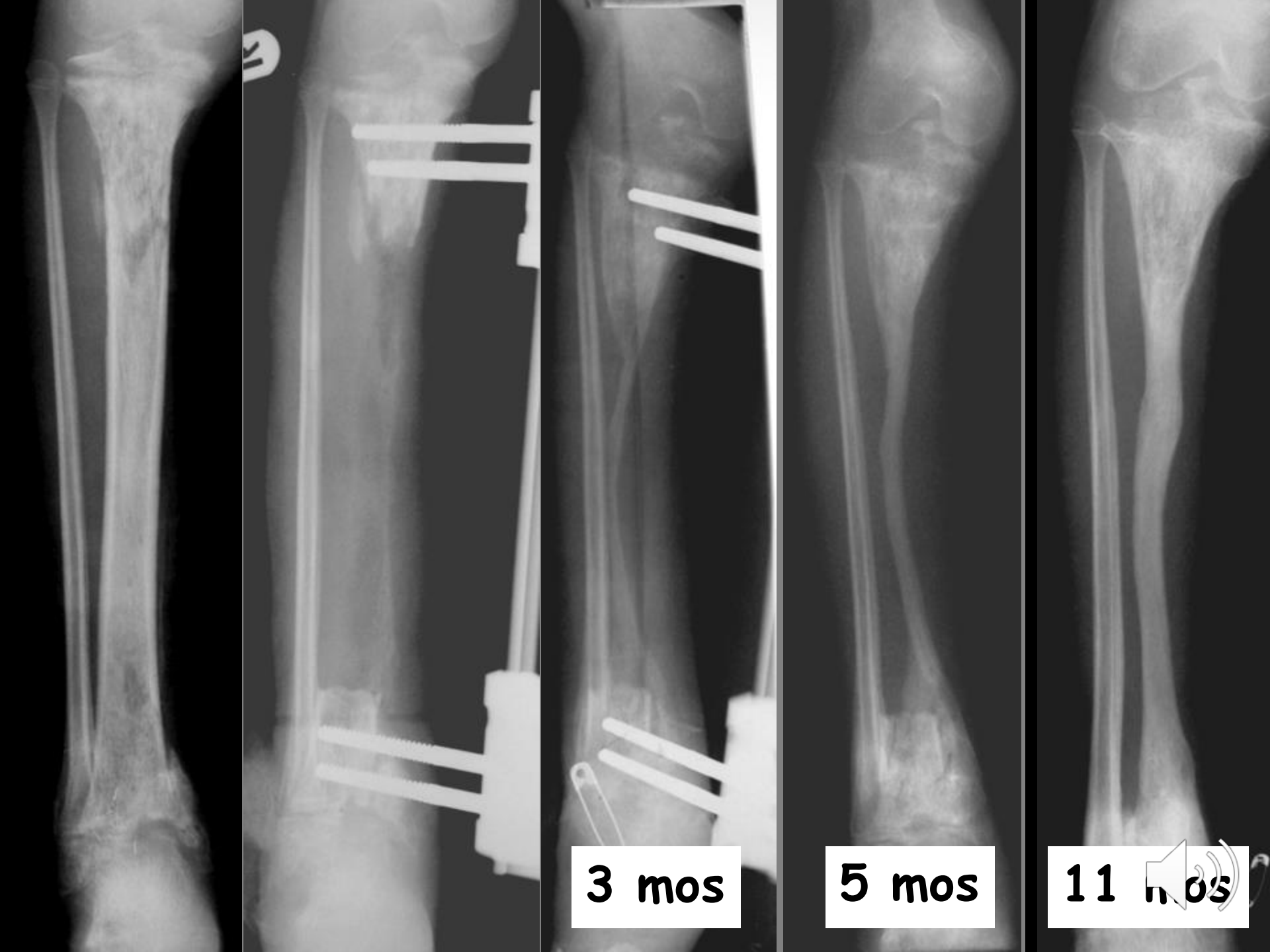







R




3 mos
5 mos
11 mos


L

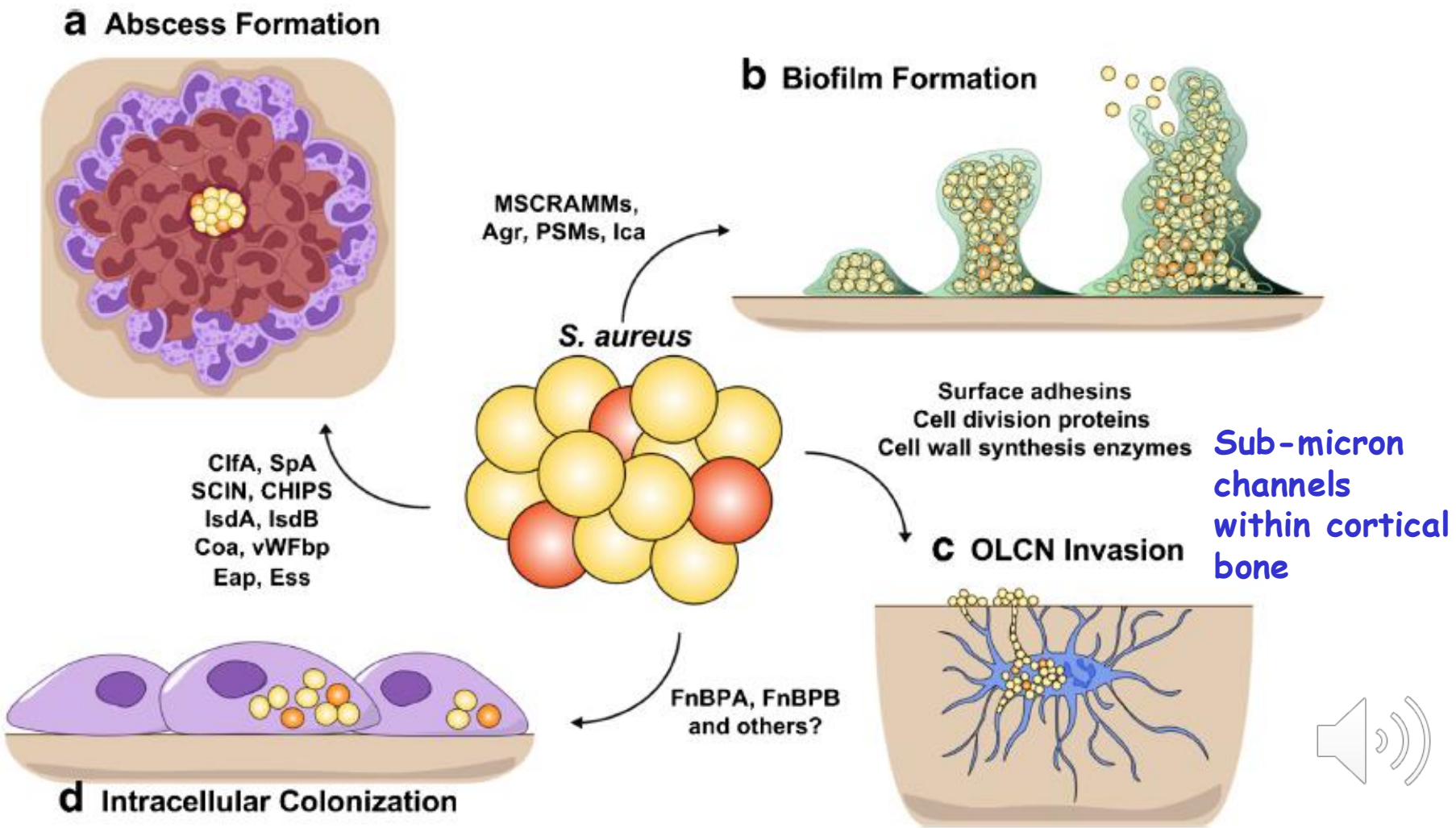
Current Osteoporosis Reports (2019) 17:395–404
https://doi.org/10.1007/s11914-019-00548-4

OSTEOIMMUNOLOGY (M NAKAMURA AND J LORENZO, SECTION EDITORS)

Check for updates

Mechanisms of Immune Evasion and Bone Tissue Colonization That Make *Staphylococcus aureus* the Primary Pathogen in Osteomyelitis

Gowrishankar Muthukrishnan [1,2] · Elysia A. Masters [1,3] · John L. Daiss [1,2] · Edward M. Schwarz [1,2,3]



Sub-micron channels within cortical bone

Pediatric Musculoskeletal Infection

Hijacking the Acute-Phase Response

JBJS REVIEWS 2016;4(9):e4

Thomas J. An, BA

Michael A. Benvenuti, BS

Megan E. Mignemi, MD

Isaac P. Thomsen, MD

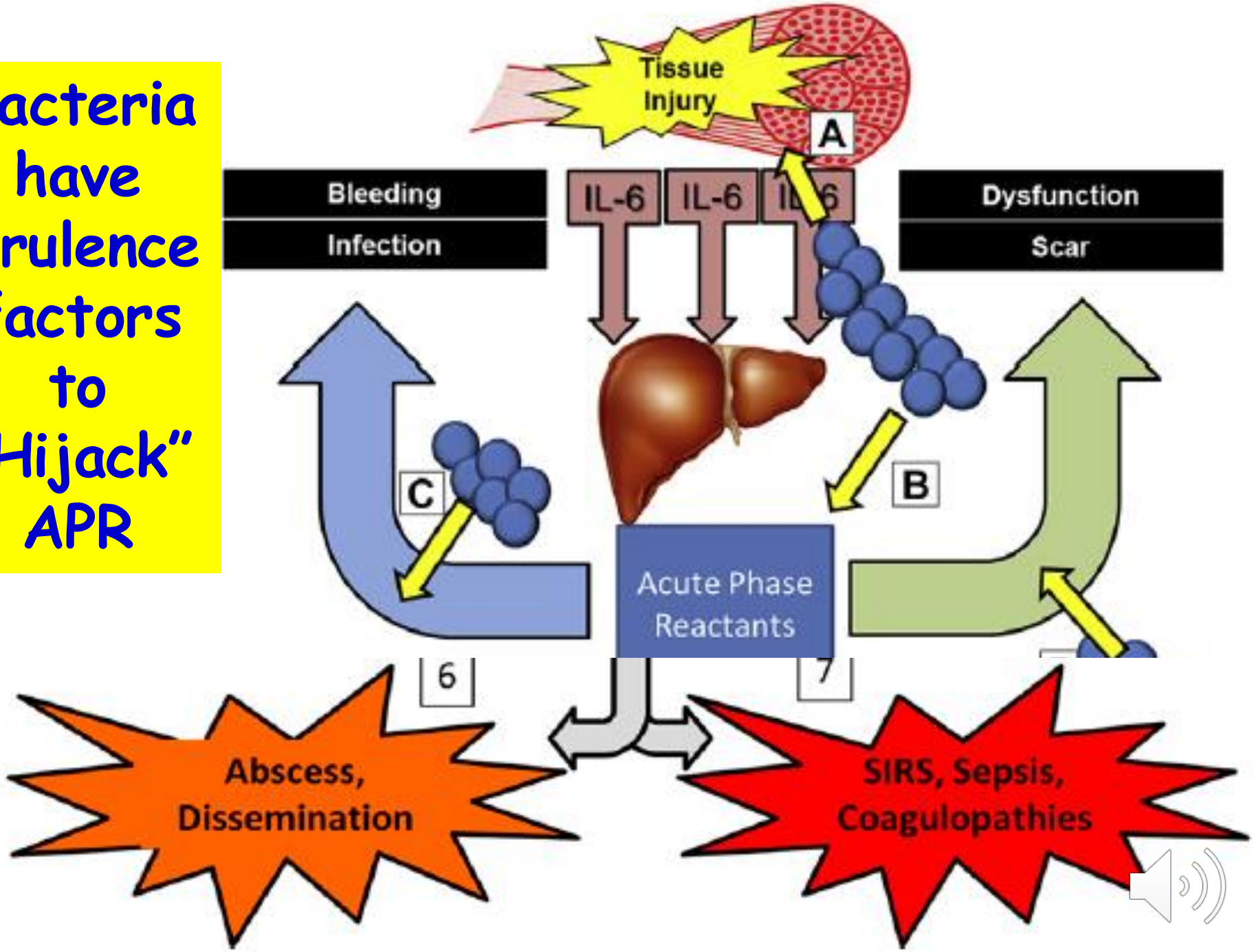
Jonathan G. Schoenecker, MD, PhD

Abstract

» Tissue injury activates the acute-phase response mediated by the liver, which promotes coagulation, immunity, and tissue regeneration. To survive and disseminate, musculoskeletal pathogens express virulence factors that modulate and hijack this response. As the acute-phase reactants required by these pathogens are most abundant in damaged tissue, these infections are predisposed to occur in tissues following traumatic or surgical injury.

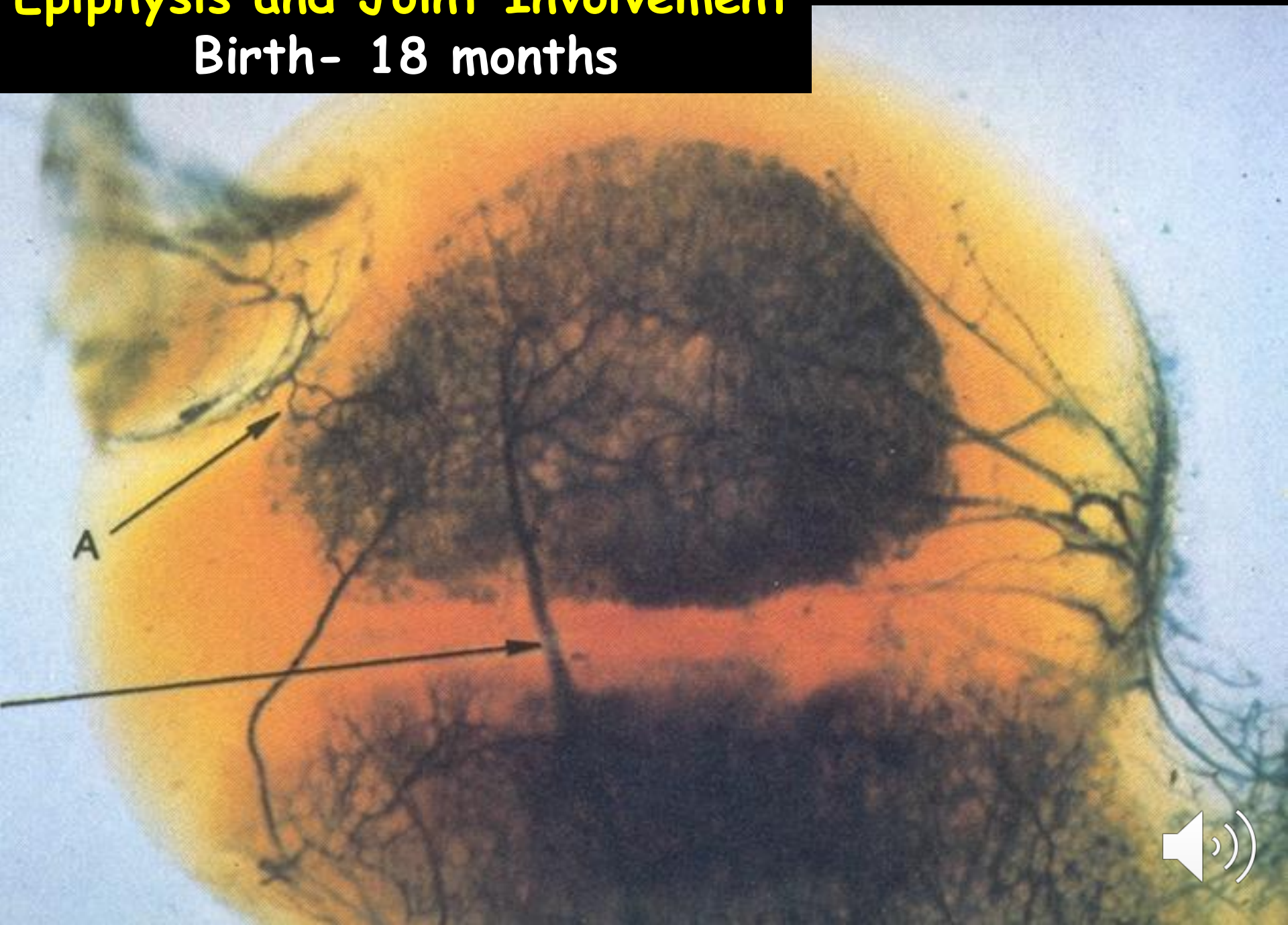
"Form of continuous tissue injury that intensely activates the acute-phase response through persistent production of IL-6"

Bacteria have virulence factors to "Hijack" APR



Epiphysis and Joint Involvement

Birth- 18 months











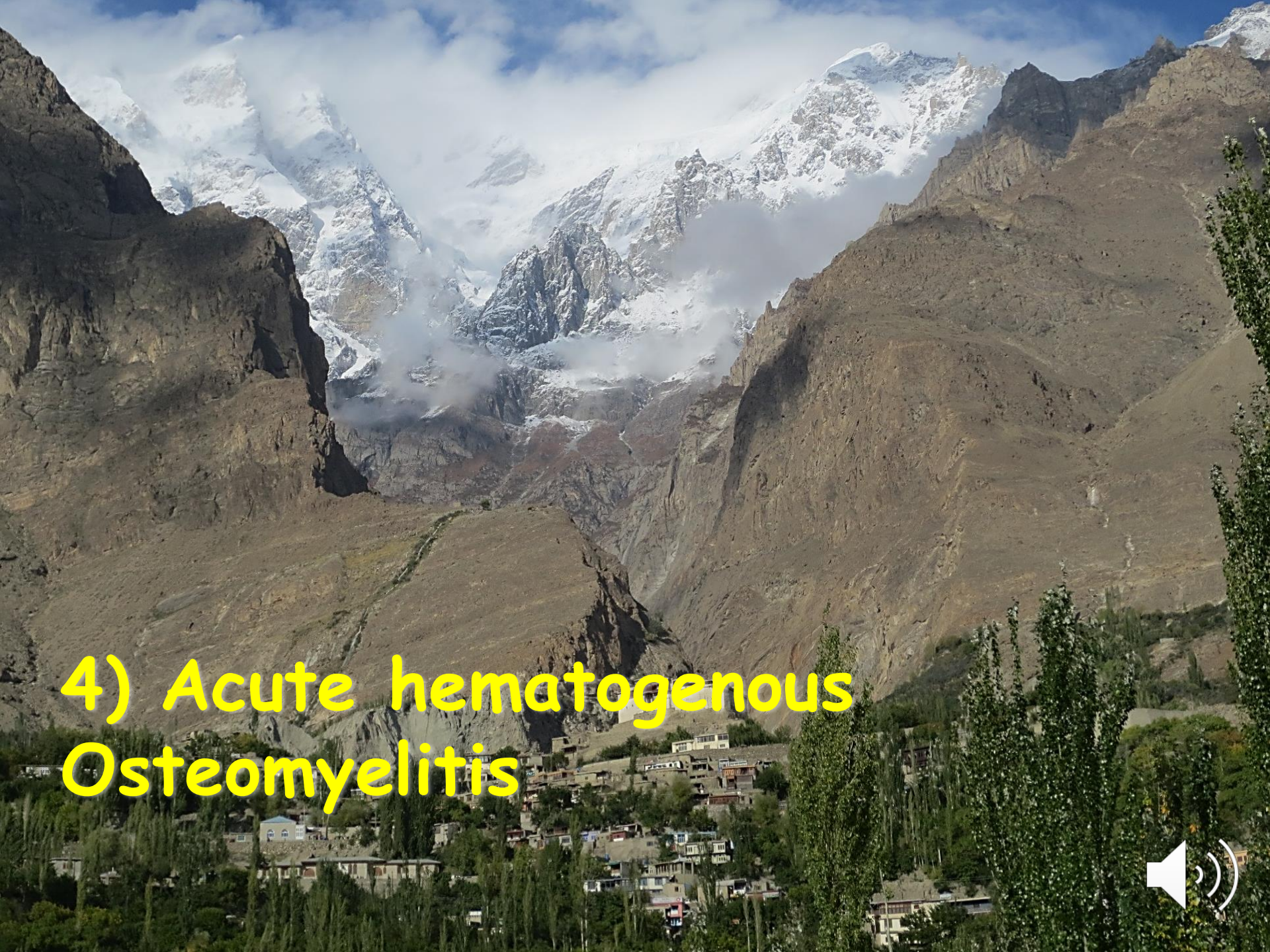






Intra-articular Metaphysis

Proximal Humerus
Proximal Radius
Hip
Distal Fibula


4) Acute hematogenous
Osteomyelitis

THE JOURNAL OF BONE & JOINT SURGERY

■ INSTRUCTIONAL REVIEW: CHILDREN'S ORTHOPAEDICS

Haematogenous acute and subacute paediatric osteomyelitis

A SYSTEMATIC REVIEW OF THE LITERATURE

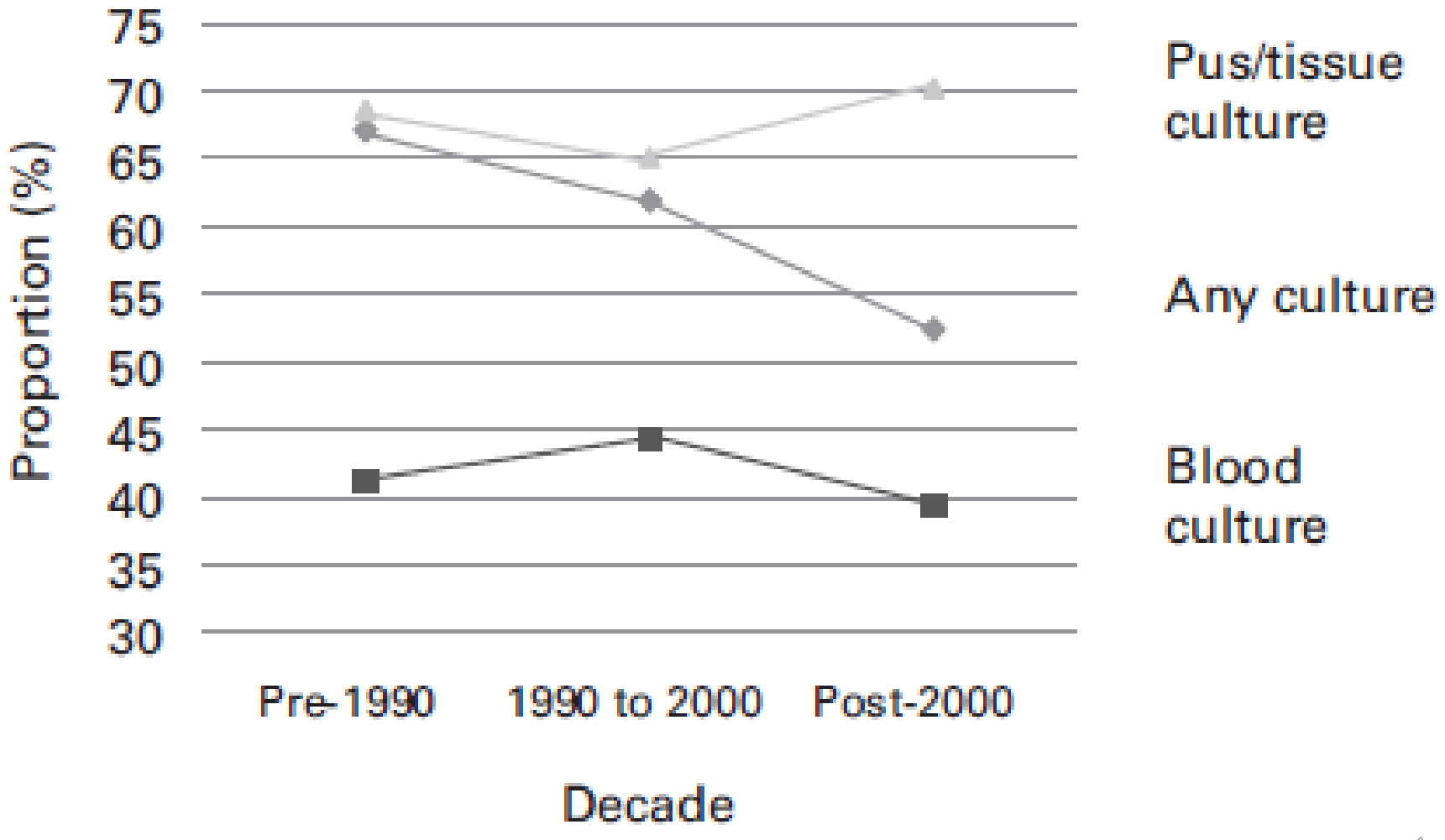
J. Dartnell,
M. Ramachandran,
M. Katchburian

A delay in the diagnosis of paediatric acute and subacute haematogenous osteomyelitis can lead to potentially devastating morbidity. There are no definitive guidelines for diagnosis, and recommendations in the literature are generally based on expert opinions, case series and cohort studies.

Table IV. Skeletal distribution of osteomyelitis

Site	Incidence* (%)	Site	Incidence (%)
Femur	*26.9*	Vertebra	*3.8*
Tibia	*26.0*	Fibula	*3.7*
Pelvis	*9.2*	Hand	*2.0*
Humerus	*8.1*	Clavicle	*0.8*
Foot	*7.7*	Rib	*0.6*
Forearm	*4.8*	Patella	*0.2*
Calcaneum	*4.6*	Other	*1.6*

* values were calculated using studies that provided adequate information to produce overall figure


75
70
65
60
55
50
45
40
35
30
Proportion (%)
Pre-1990
1990 to 2000
Post-2000
Decade
Pus/tissue culture
Any culture
Blood culture

Patient Characteristics	Causative Organisms
Nosocomial infection	*S aureus*, Streptococci species, Enterobacteriaceae, Candida species
Community-acquired infection	*S aureus*, group B Streptococcus, *Escherichia coli*, Klebsiella species
Infantile (2–18 mo)	*S aureus*, *K kingae*, *Streptococcus pneumoniae*, *Neisseria meningitidis*, *Haemophilus influenzae* type b (nonimmunized)
Early childhood (18 mo to 3 y)	*S aureus*, *K kingae*, *Streptococcus pneumoniae*, *Neisseria meningitidis*, *Haemophilus influenzae* type b (nonimmunized)
Childhood (3–12 y)	*S aureus*, group A β-hemolytic streptococcus
Adolescent (12–18 y)	*S aureus*, group A β-hemolytic streptococcus, *Neisseria gonorrhoeae*

Funk SL, Copley LAB. Ortho Clin North Am 2017;48:199-208.



Patient Characteristics	Causative Organisms
Nosocomial infection	*S aureus*, Streptococci species, Enterobacteriaceae, Candida species
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Funk SL, Copley LAB. Ortho Clin North Am 2017;48:199-208.

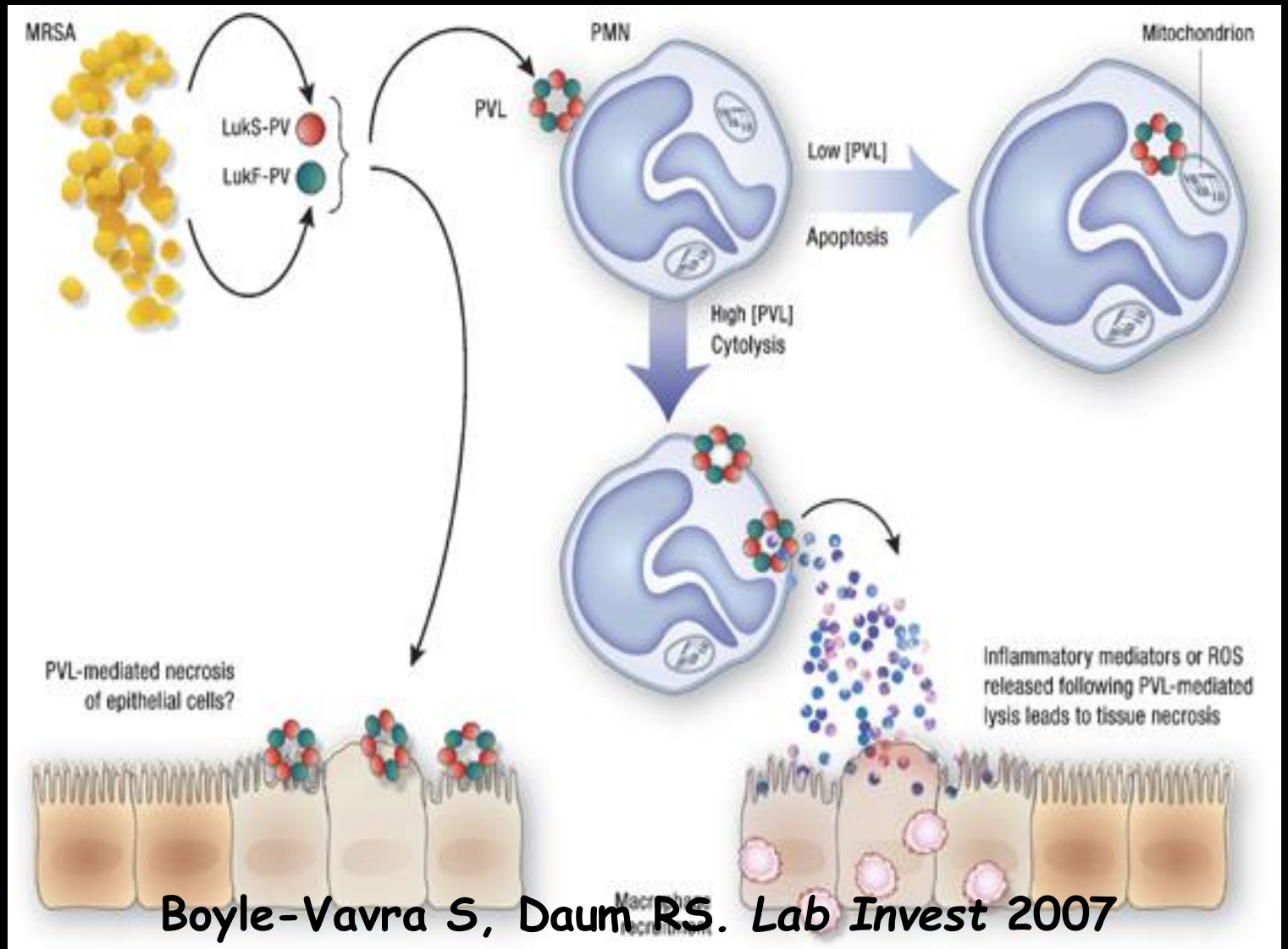


Higher virulence (VRE, MRSA)

- Iatrogenic (overuse and misuse)
- MRSA: ↑ surgery, ↑ complications
  - Multifocal
  - DVT/Septic emboli
  - Multi organ failure

Panton-Valentine Leukocidin Gene(*pvl*)

- MSSA, CA-MRSA (66-100%), HA-MRSA (<5%)



Boyle-Vavra S, Daum RS. *Lab Invest* 2007

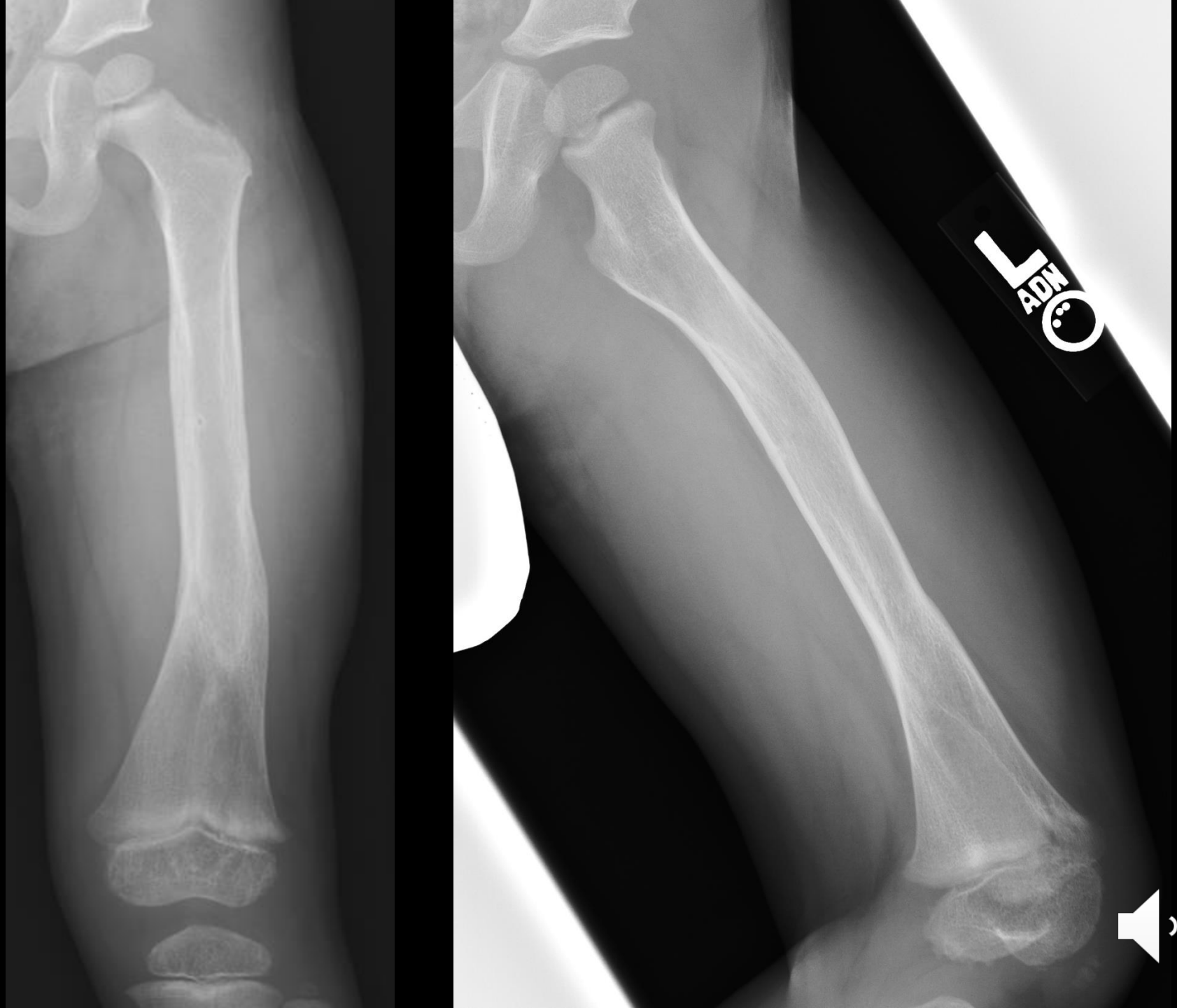
Case Study:
Natural History of treated AHO











L
ADN




5) Drugs

Antibiotics

- Empiric
  - Based on age, history, local flora
  - Modify based upon cultures
- Duration of treatment
  - Etiology, extent of infection, clinical and laboratory response
  - Shorter duration IV based on clinic exam and CRP




6) The Host

Surgical Treatment of Osteomyelitis

George Cierny, III, M.D.
San Diego, Calif.

Summary: Chronic osteomyelitis is refractory to nonsurgical treatment due to a resilient, infective nidus that harbors sessile, matrix-protected pathogens bound to substrate surfaces within the wound. Curative treatment mandates physical (surgical) removal of the biofilm colony, adjunctive use of antibiotics to eliminate residual phenotypes, and efforts to optimize the host response throughout therapy. Patient selection, therapeutic options, and the treatment format are determined by the Cierny/Mader staging system, while reconstruction is governed by the integrity/stability of the affected bone(s) and quality/quantity parameters of the soft-tissue envelope. (*Plast. Reconstr. Surg.* 127 (Suppl.): 190S, 2011.)

A= Healthy
B = Co-Morbidities
C = Risk > benefit

Table 1. Patient Comorbidities and Outcomes*

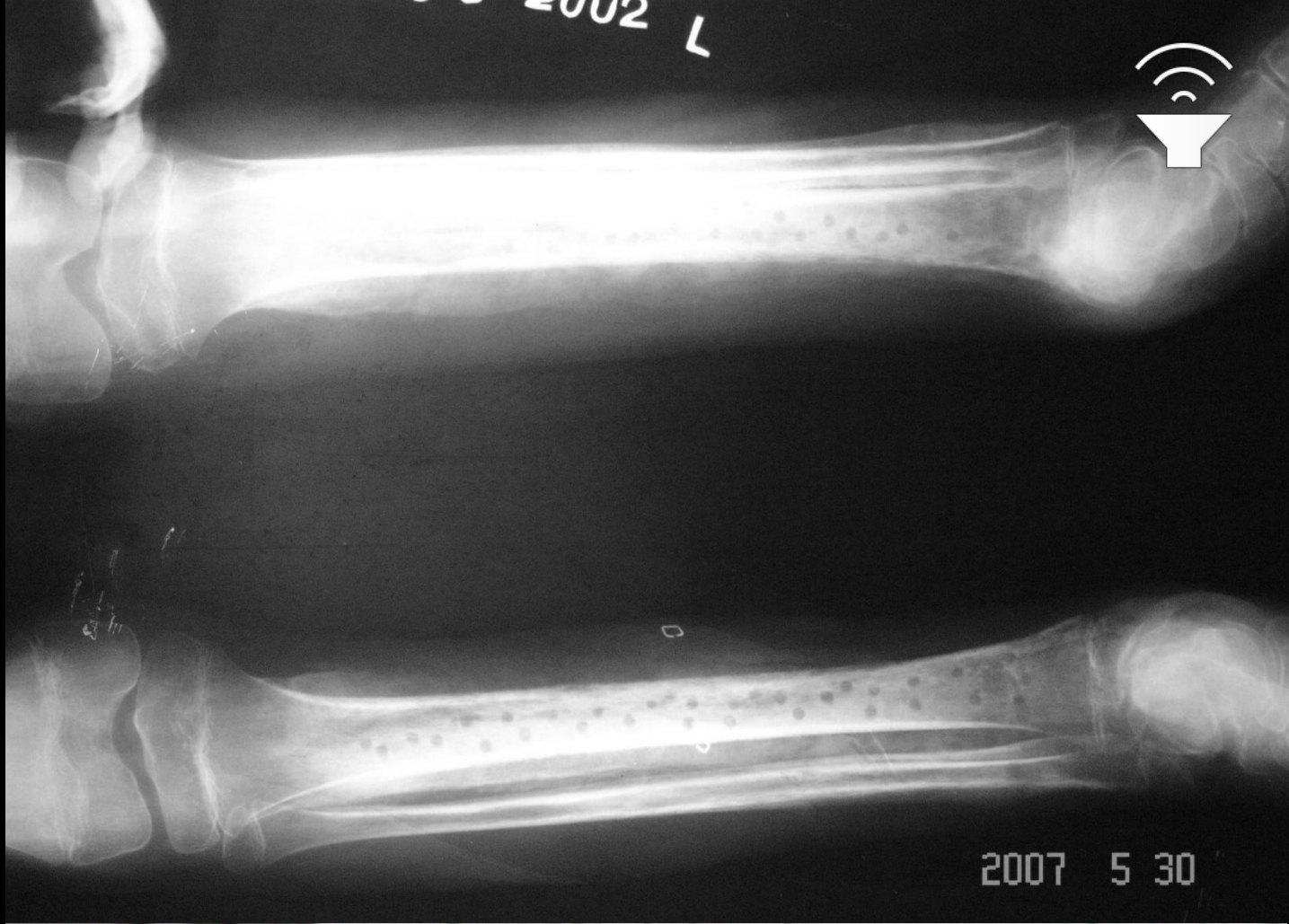
Local factors
Chronic edema
Venous stasis
Large vessel disease
Arteritis
Extensive scar
Radiation fibrosis
Obesity
Foreign body excess†
Systemic factors
Malnutrition
Immune deficiency
Hypoxia
Malignancy
Diabetes
Old age
Organ failure
Bleeding diathesis
Nicotine abuse
Intravenous drug abuse
Drug inhibitors‡
Skin colonization

Reversible AIDS








2002
L
2007 5 30






2005 4 11



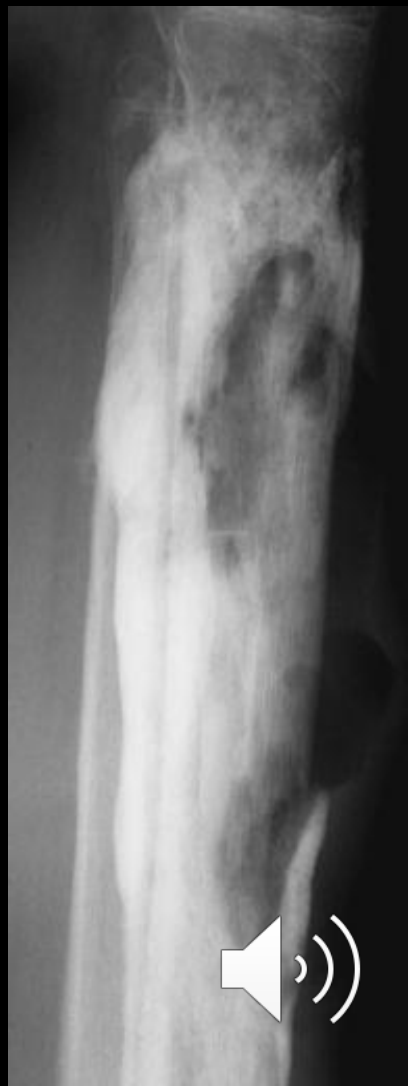




7) Indications and Timing of surgery

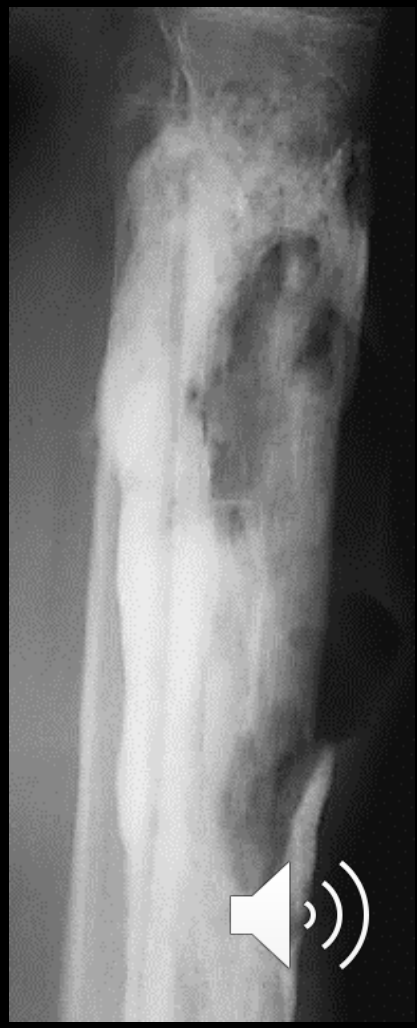
Acute Presentation

- Source contro
  - Drain Abscess
  - Debride Bone Destruction
  - Lack of response to empiric antibiotics
- Coexisting septic arthritis
- Diagnostic dilemma



Subacute or Chronic Presentation

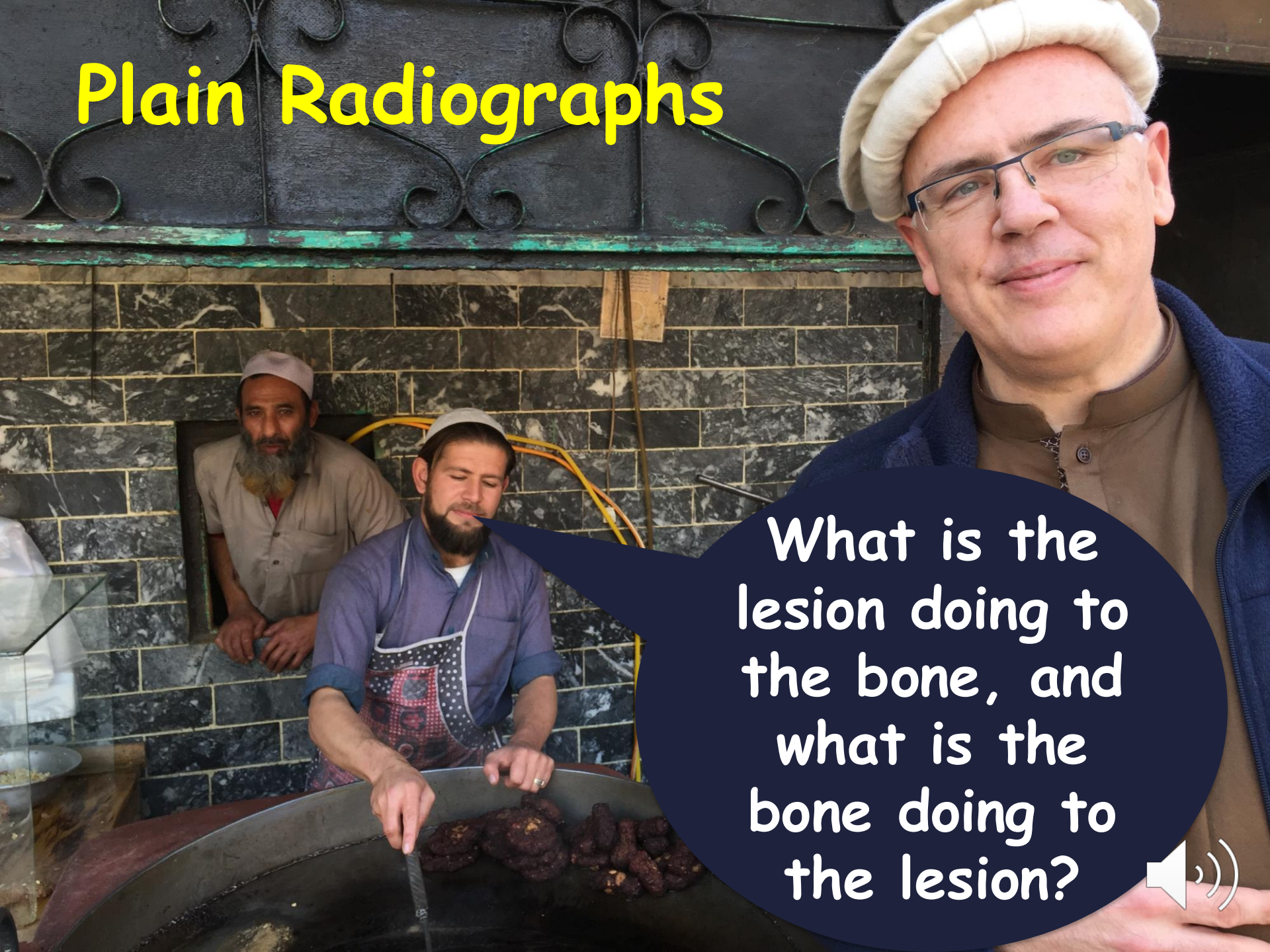
1) Diagnosis unclear
2) Reasonable chance of eradication or DFS
3) Containment or address disease reactivation
4) Complications



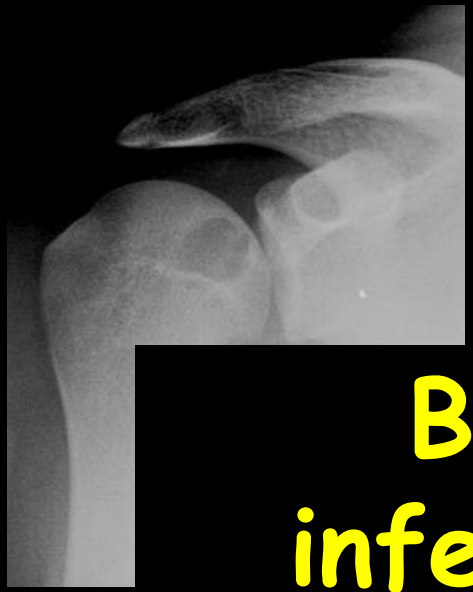
Diagnostic Dilemmas



Plain Radiographs



Chondroblastoma vs. Epiphyseal Osteomyelitis





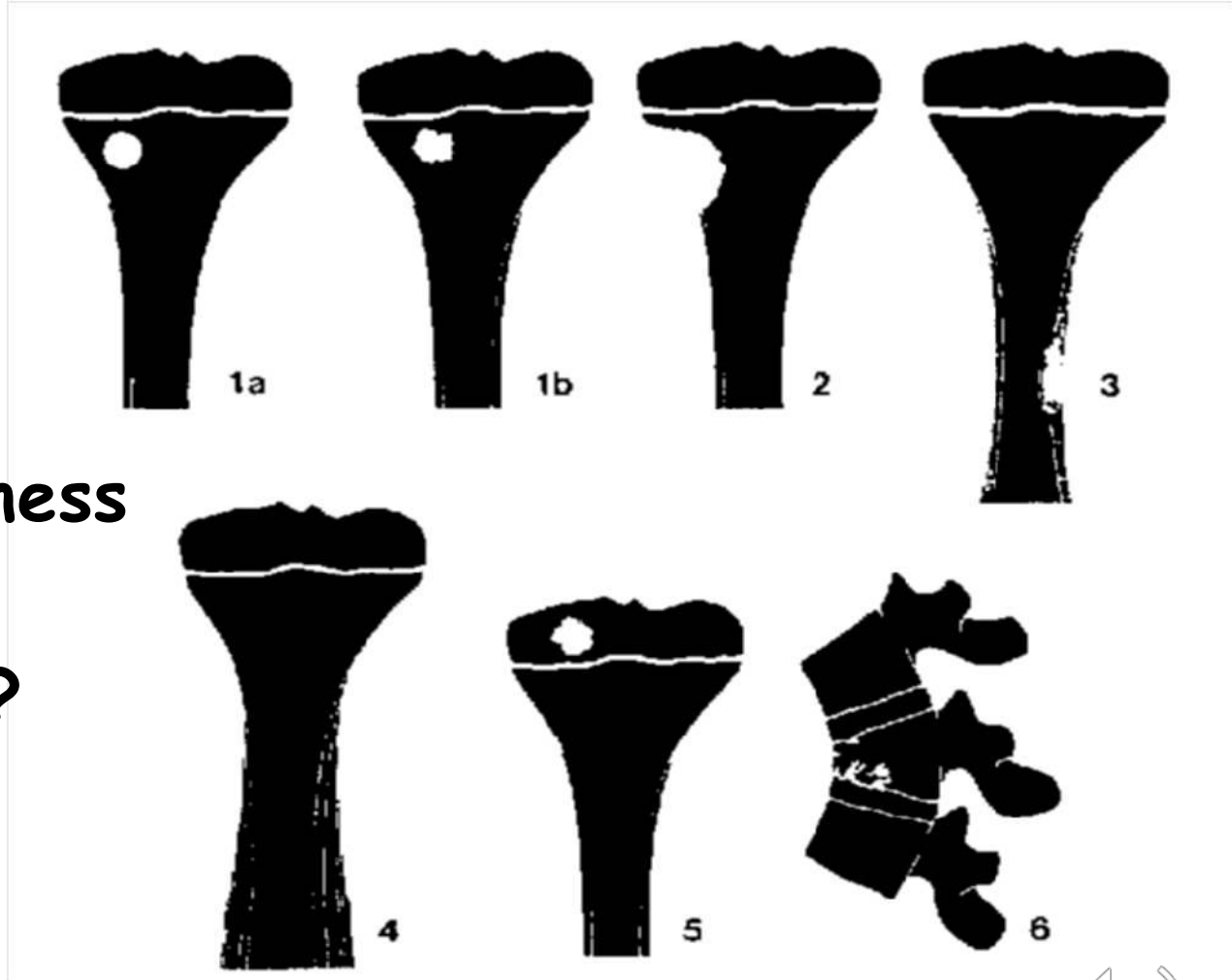
Biopsy all infections and culture all tumors!





Subacute Hematogenous Osteomyelitis

- Weaker bug, stronger host
- Insidious pain
- No systemic illness
- Normal labs
- Abx vs. Biopsy?



Roberts JA, Drummond DS, et al. J Ped Ortho 2:249, 1982

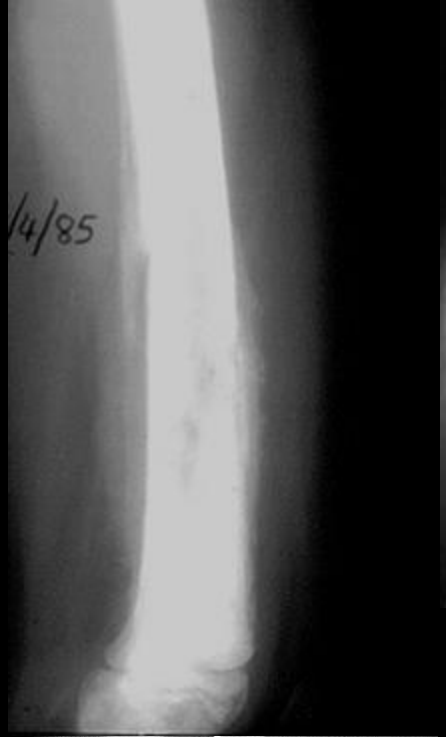


Can also look aggressive…..



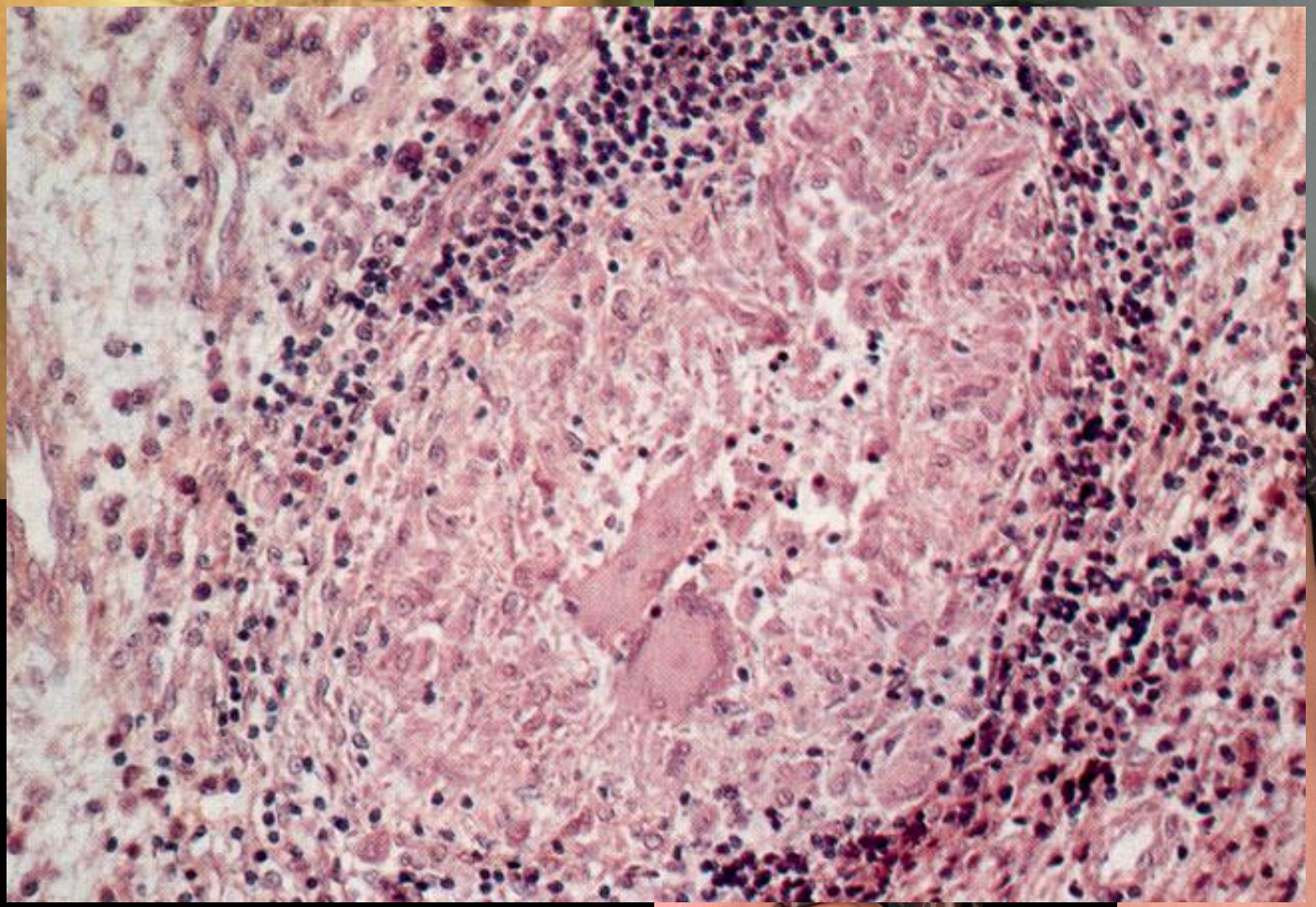












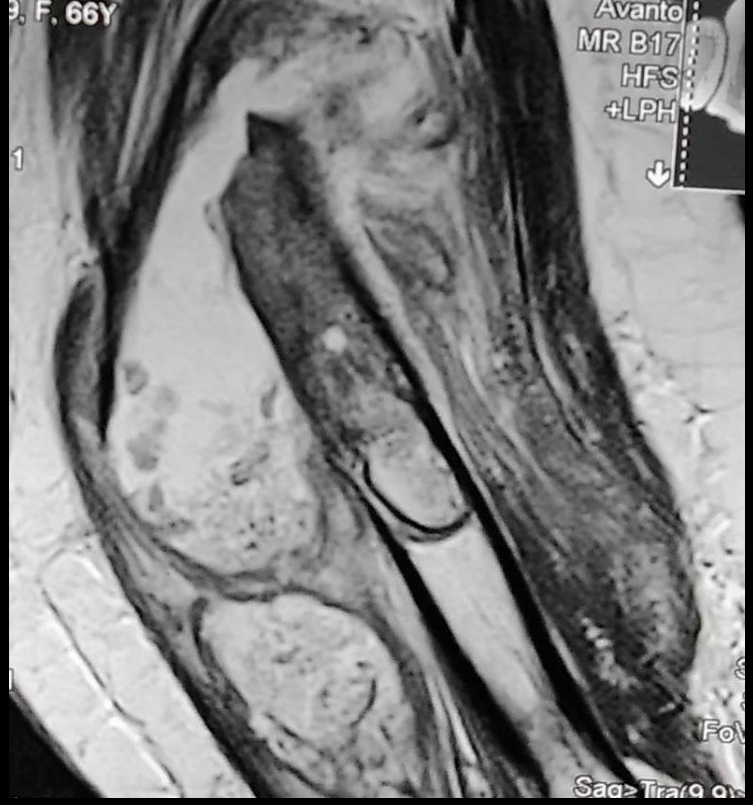






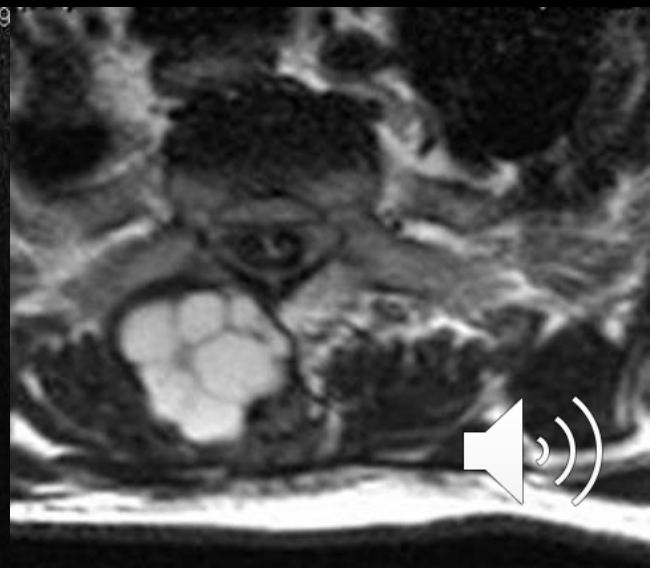

HRDC L 1736

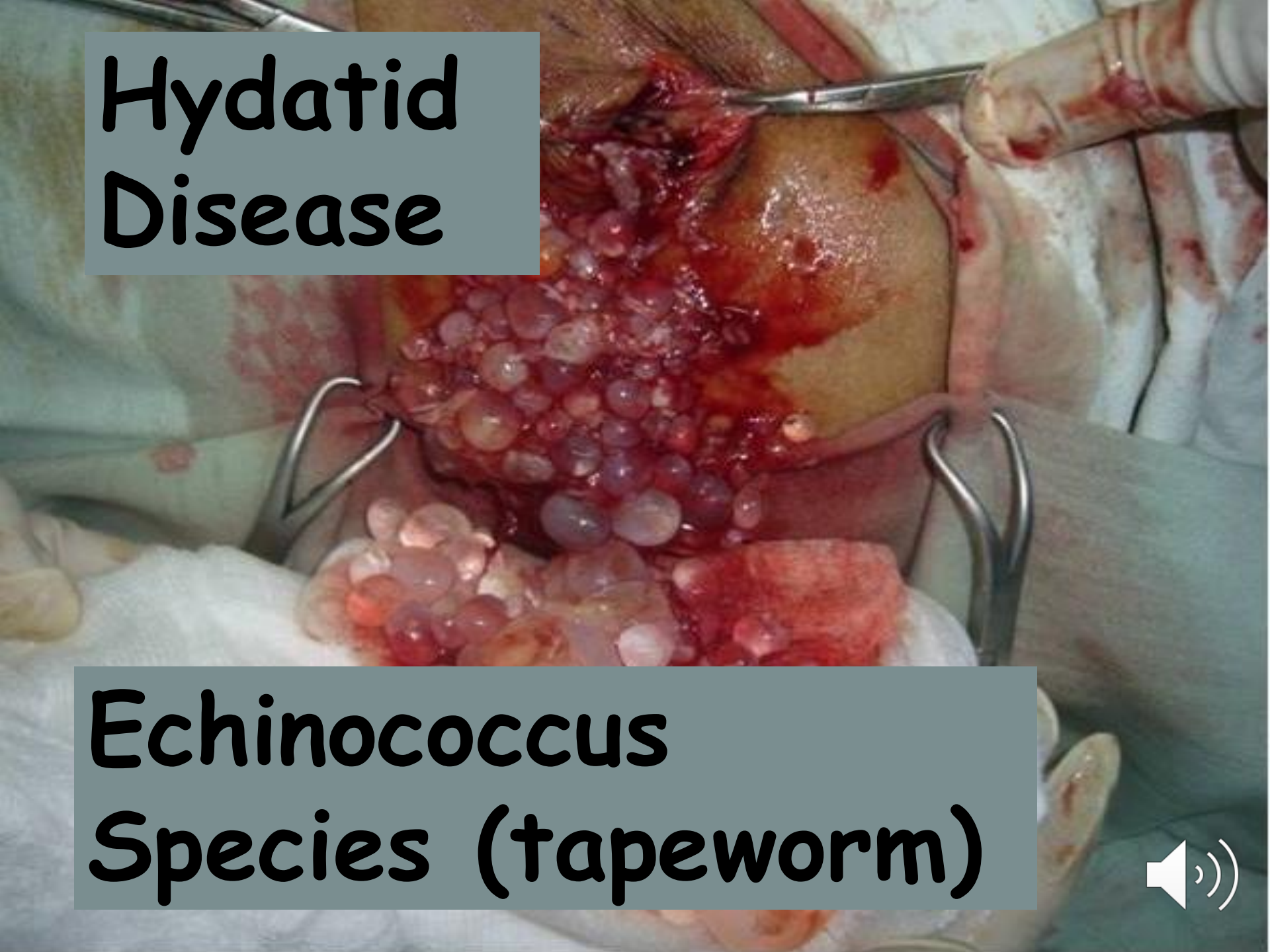



F, 66Y
Avanto
MR B17
HFS
+LPH


Acq Tm: 09:25:33.71
L
A
ET: 17
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TE: 120.0

Sag R11.4 (COI)
336 x 145


Acq Tm: 09



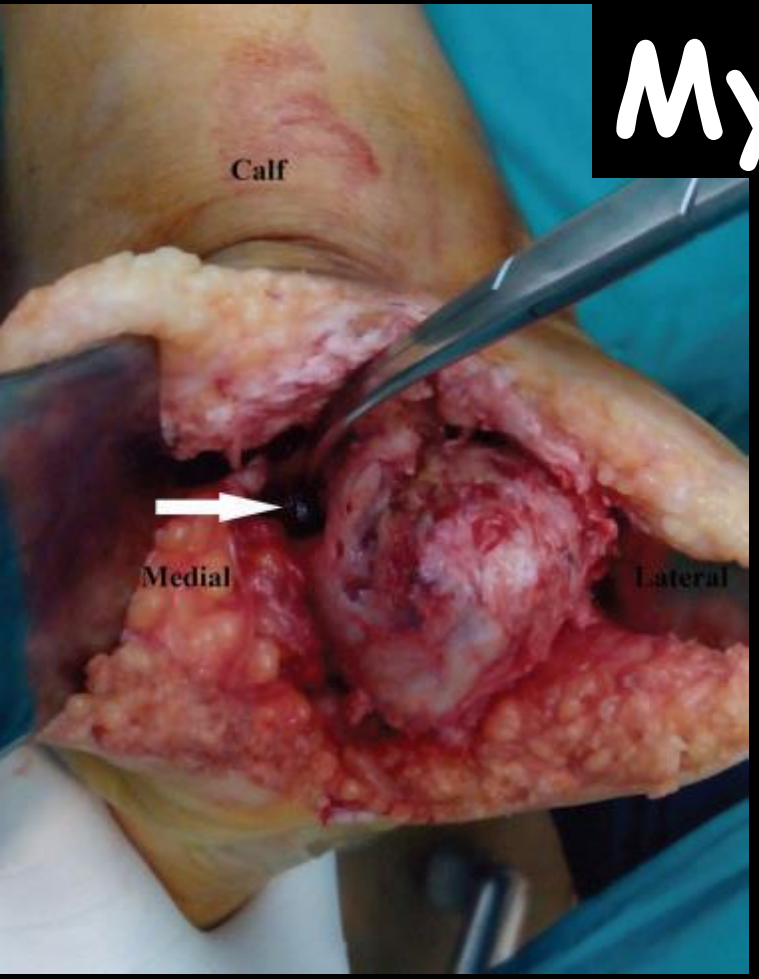
Hydatid Disease

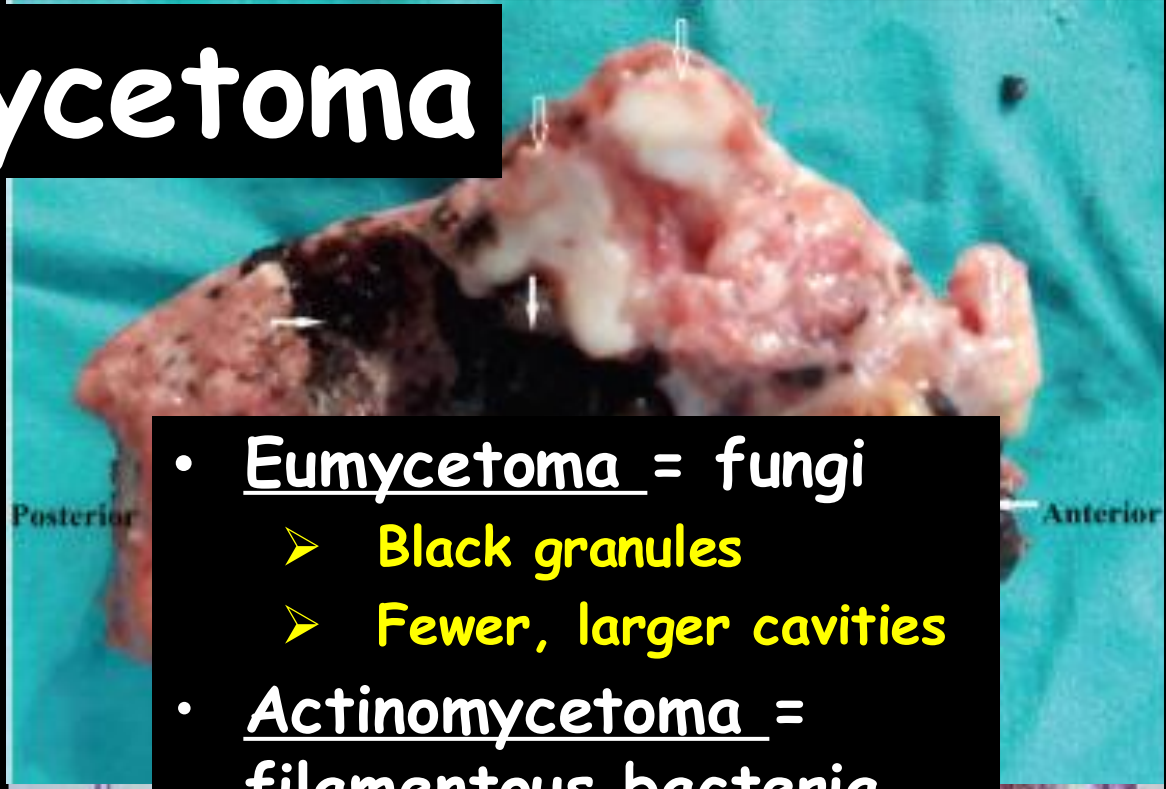
Echinococcus Species (tapeworm)



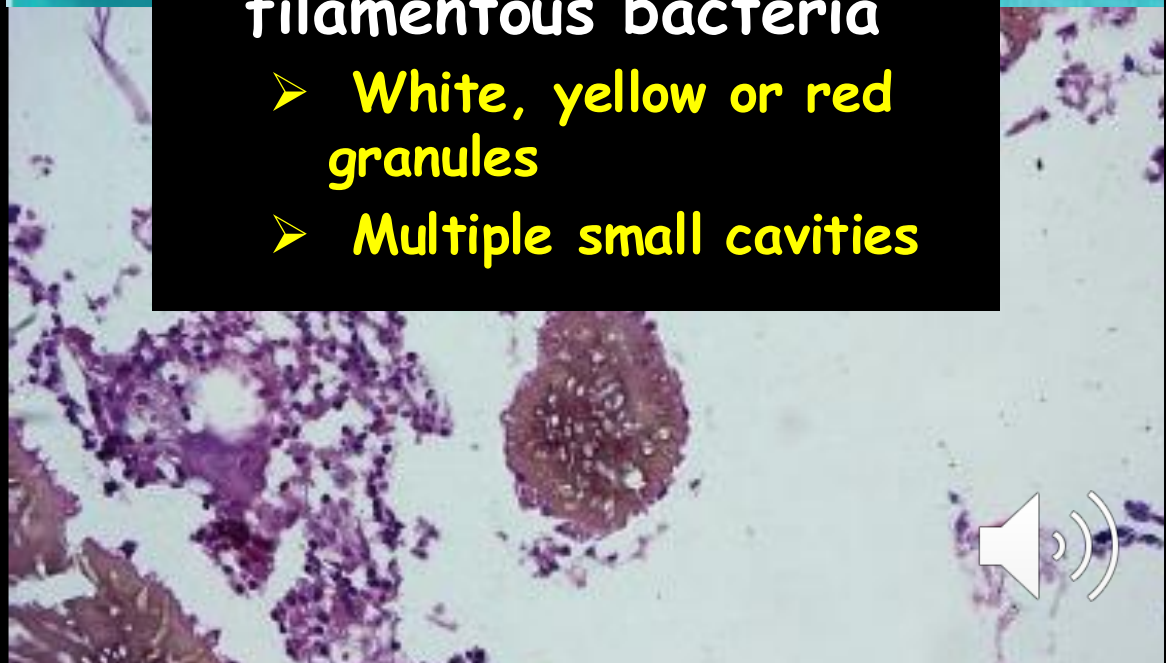


Mycetoma





- Eumycetoma = fungi
  - Black granules
  - Fewer, larger cavities
- Actinomycetoma = filamentous bacteria
  - White, yellow or red granules
  - Multiple small cavities



El-Sobky TA, et al. Case Reports in Pathology 2015;129020

8) "Chronic" Osteomyelitis



Disease state with standoff between organisms and host

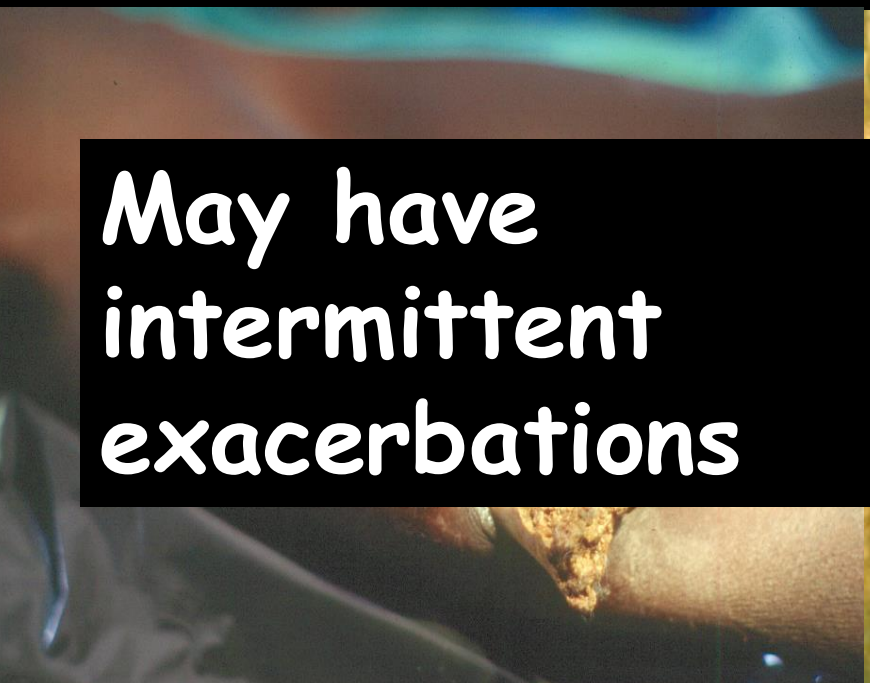




Neither the host defenses nor gorillacillin can get to them



May have intermittent exacerbations







1. Debridement
2. Dead space management
3. Coverage
4. Treat complications



- Minimize subperiostial dissection
- Debride (“*Paprika sign*”)
- Repeat if necessary
- Cover cavity with muscle if available



Timing



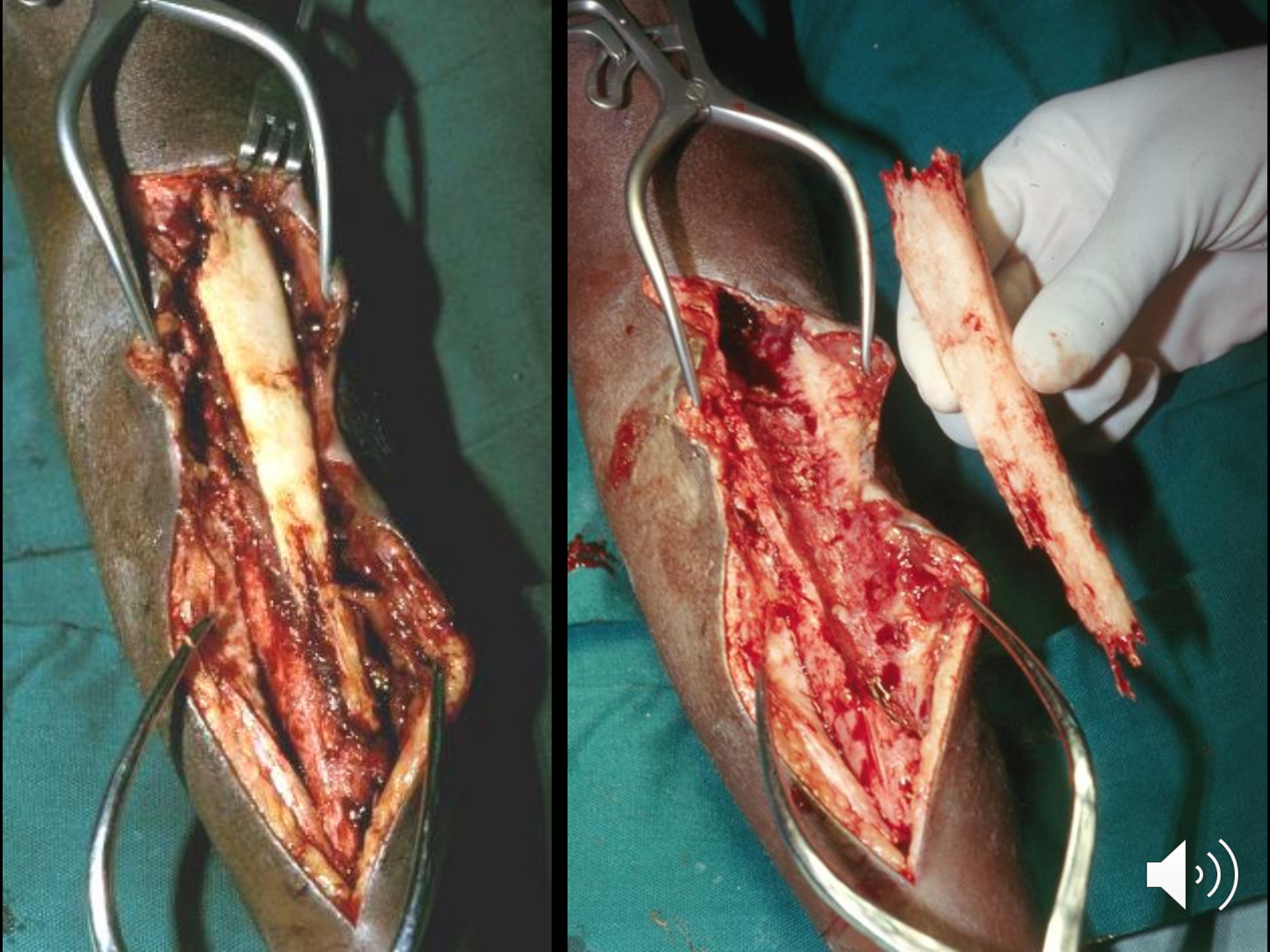










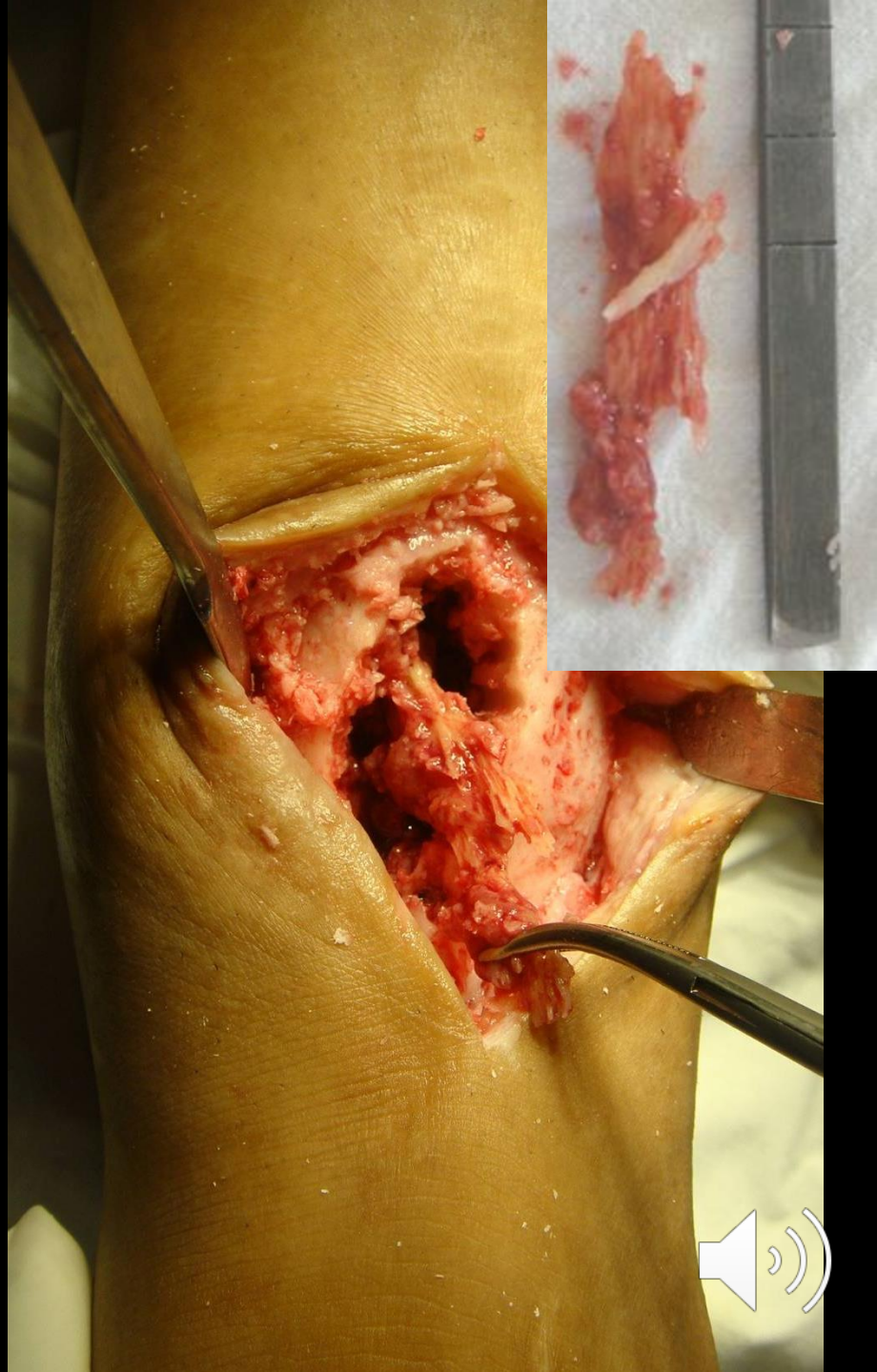



R72









Extensive involvement and no obvious sequestrae?

Consider IM reaming




9) Managing Complications

Pathologic Fracture: Prevention vs. Treatment















Focal Bone Loss















Segmental Bone Loss









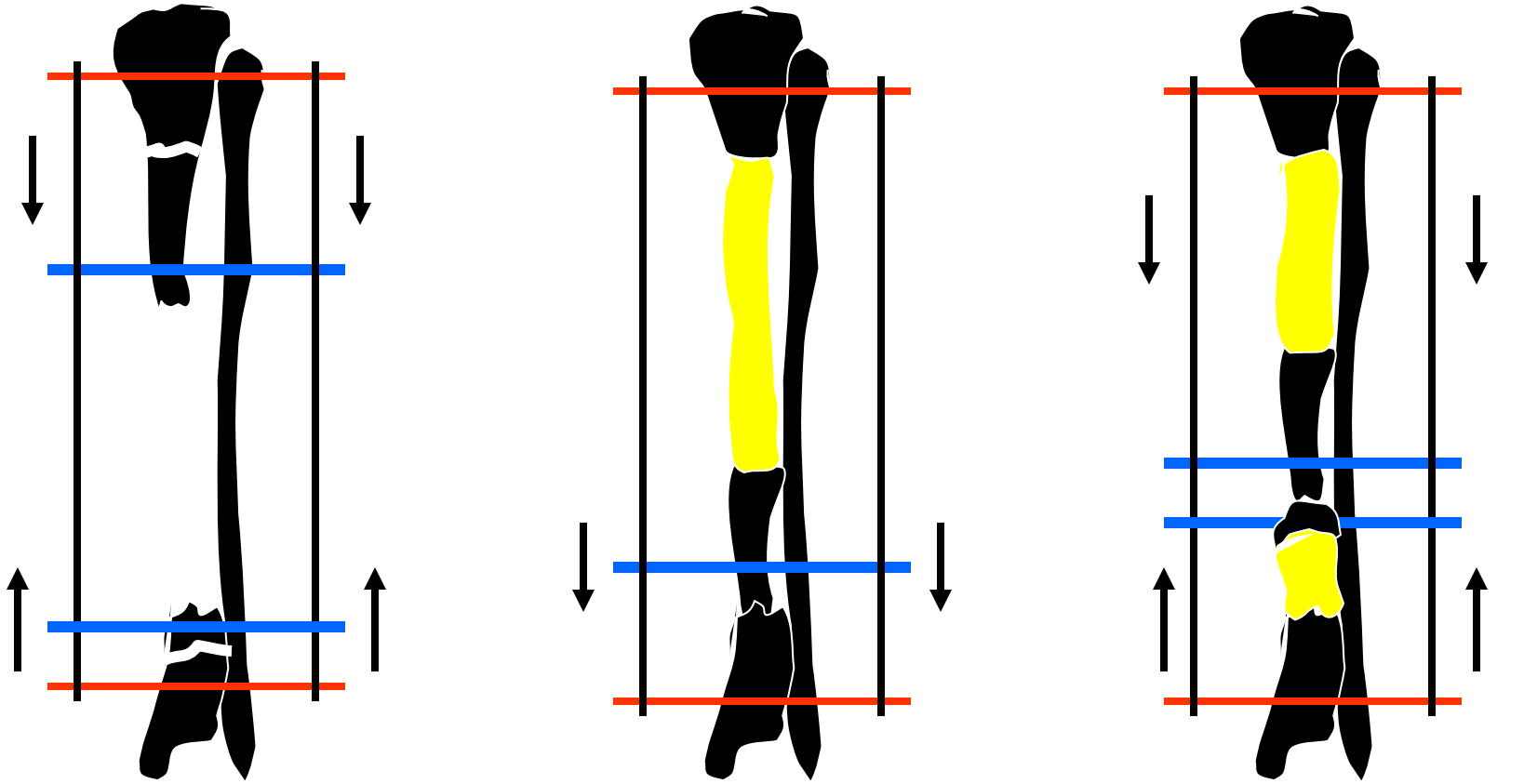


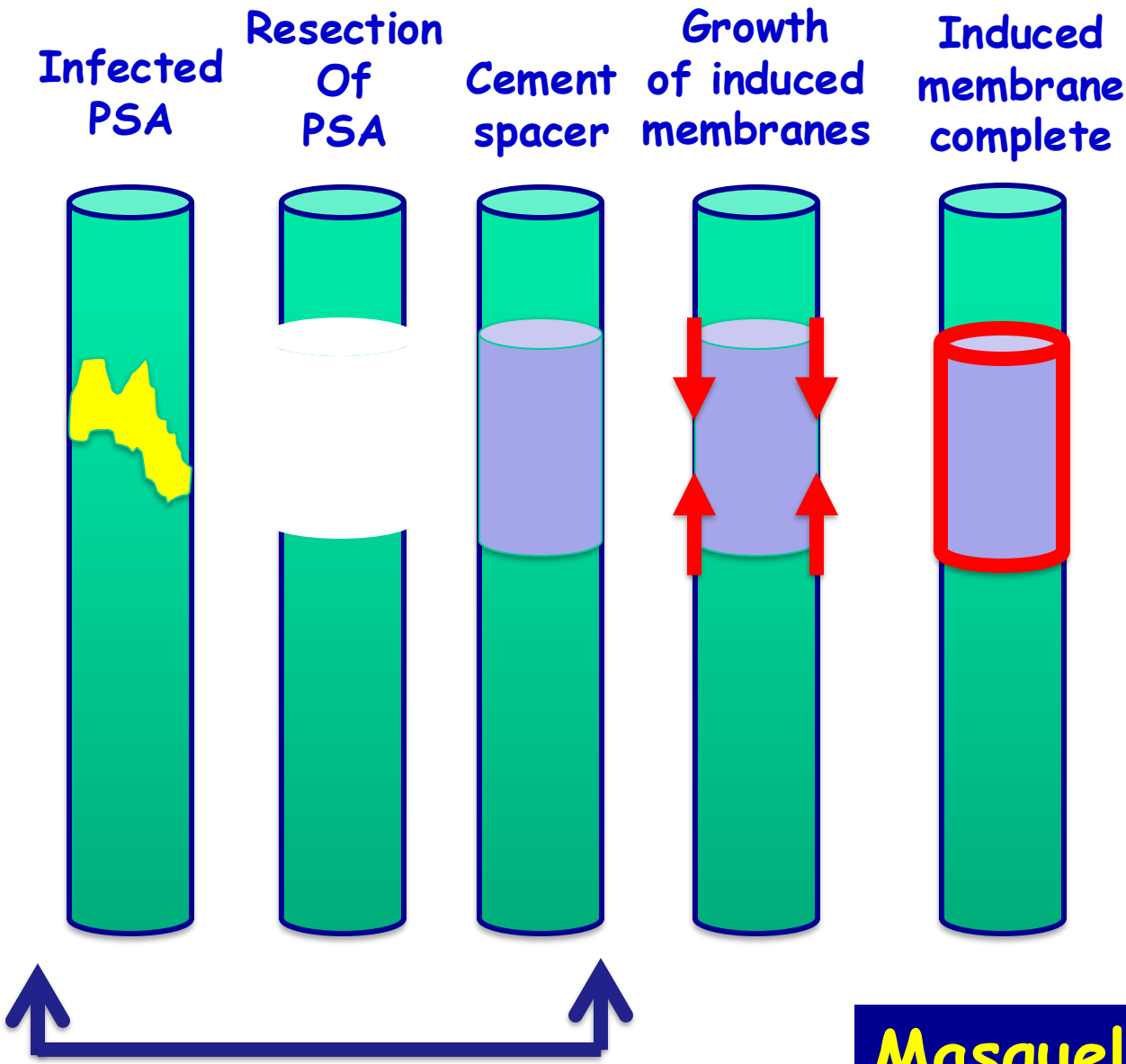






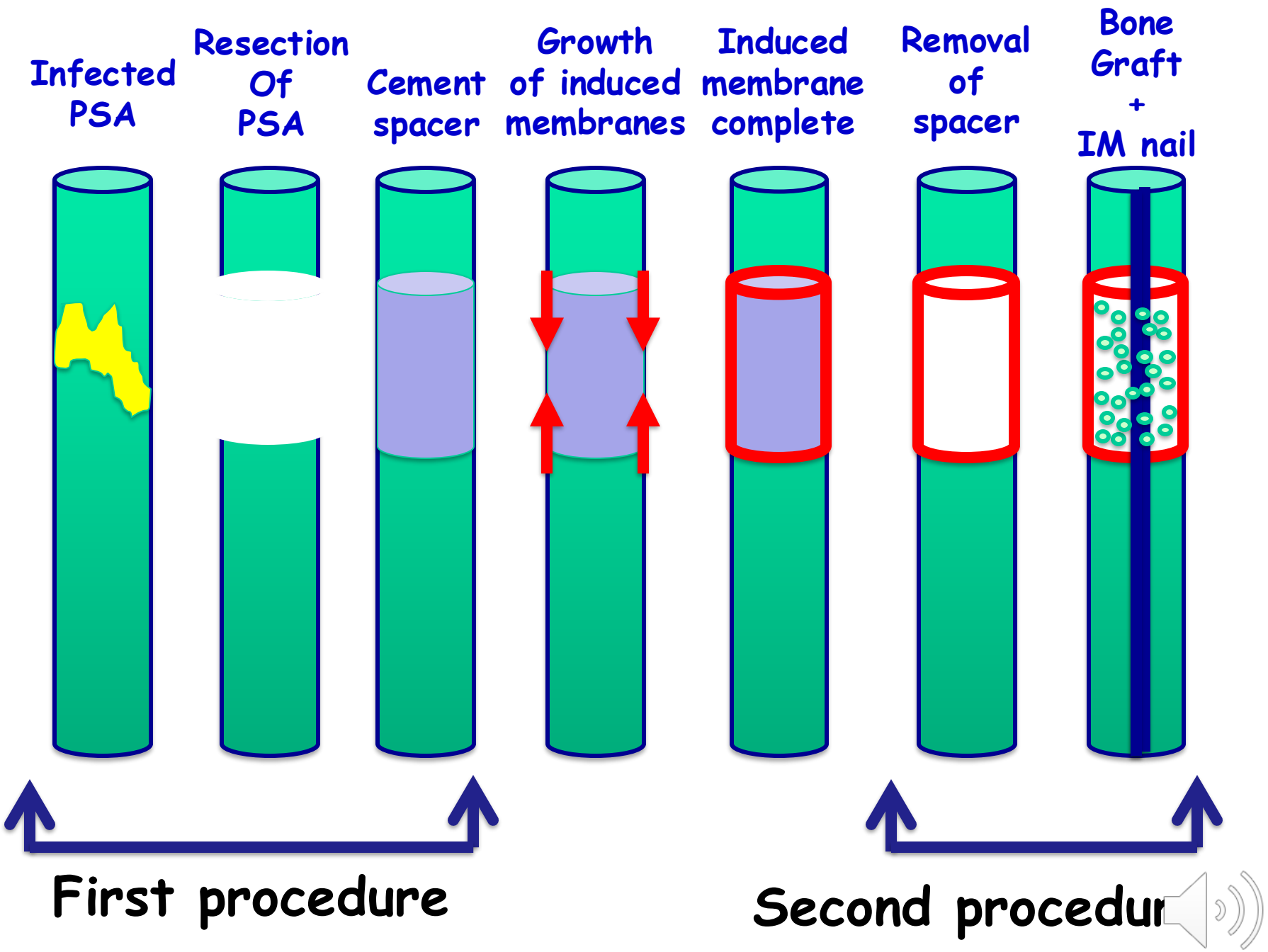
Bone Transport





Courtesy of Richard Gosselin MD

Masquelet: Induced Membrane Technique


Infected PSA
Resection Of PSA
Cement spacer
Growth of induced membranes
Induced membrane complete
Removal of spacer
Bone Graft + IM nail
First procedure
Second procedur
Courtesy of Richard Gosselin MD

Summary

- Spectrum of pathology based on organism, host, treatment, and chronicity
- Organisms manipulate the normal response to tissue damage to their benefit
- AHO: Staph and now Kingella, Abx for shorter duration with early switch to or

Summary

- Surgical indications include Dx, local disease control, complications
- Chronic cases treat as a tumor, wide resection and reconstruction
- Multiple complications include bone loss, limb length discrepancy, and/or angular deformity


Thanks!