Charcot Neuroarthropathy

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Important Points

- Recognize Charcot (Patient, Presentation, Stages)
- Differential Diagnosis
- Diagnostic Strategies
- Non-Surgical Modalities
- Understand Surgical Challenges
- Management in Long-Term
Charcot Statistics

- 60-70% diabetics neuropathic
- Often misdiagnosed, overlooked!
- Duration of diabetes >10 years
- B/L 6-40%
- Progressive deformity, ulceration, infection, amputation, death
Etiology

- Diabetes most common cause
- Tabes dorsalis
- Syringomyelia
- Leprosy
- Polio
- Pernicious Anemia
- Pott’s Disease

- Spinal chord tumors
- Paraplegia
- Alcohol abuse
- Extrinsic compression of spinal cord
- MS
- Chemo-Therapy
- Spina Bifida
French Neurovascular Theory

- Neurally initiated vascular reflex. "Autosympathectomy"
- High rate of flow produces AV shunting
- Bone demineralization and breakdown.
- Bone resorption by osteoclasts.
- Hyperemia with secondary pathologic fractures

*With continued WB on insensate foot, the Neurotraumatic mechanism occurs.*
German Neurotraumatic Theory

- Bone and joint changes caused by repetitive foot trauma on an insensate foot.

- **Trauma (Minor/Major)**
  - Repetitive moderate stress
  - Repetitive impulse loading
  - Trabecular microfractures
  - Inadequately protected fractures/sprains
  - Surgery
What Factors Contribute to Charcot?

- **NEUROPATHY: “100%”**

- Increased local blood flow (A-V Shunting)

- Increased plantar foot pressures (Deformity/Equinus)

- Continued repetitive stress/trauma

- Non-Enzymatic Glycosylation
• Lack of perception of 4/10 sites (SWMF), carries 97% sensitivity and 83% specificity in identifying patients at highest risk for diabetic foot ulcers.

• **Vibration** perception, yielding 90% sensitivity and 84% specificity in detecting neuropathy.

• When both of these used the sensitivity increased to 100% and specificity 77%.
Neuropathy’s Role

Motor
- Denervation of intrinsic muscles
- Contractures
- Deformities, digital deformities
- Gait Abnormalities; Drop foot, EQUINUS

Autonomic (Sudomotor)
- Etiologic factor in soft tissue and bony lesions
- Abnormalities in regulation of temperature and sweating
- AV-Shunting
- Hypothesis: “Autosympathectomy”

Sensory: Most Important!
- Leading factor in fractures, ulcers, injuries
Recognition of Charcot

- Must have high index of suspicion
  - PMH
  - History of trauma/surgery
  - Symptoms
  - Clinical Presentation
Charcot Joint Disease

The Medical History General

Patient Profile

Diabetes – 15 years
Poor Control
Renal Failure
5th or 6th Decade
Sex predilection?
Bilateral 6 – 40 %

Primary Risk Factors

Retinopathy
Nephropathy
Neuropathy

Secondary Risk Factors

Obesity
Biomechanics
Lifestyle
Trauma
# Acute Charcot Presentation

## Clinical Presentation Extremity

<table>
<thead>
<tr>
<th>Clinical</th>
<th>Labs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erythema</td>
<td>WBC Possibly Slightly Elevated</td>
</tr>
<tr>
<td>Warmth</td>
<td>Differential: no Left Shift</td>
</tr>
<tr>
<td>Swelling/Edema</td>
<td>Glucose normally elevated</td>
</tr>
<tr>
<td></td>
<td>ESR/CRP normally elevated</td>
</tr>
<tr>
<td></td>
<td>Alkaline Phosphatase normally elevated</td>
</tr>
<tr>
<td></td>
<td>Creatinine usually elevated</td>
</tr>
<tr>
<td></td>
<td>Blood Cultures negative if only Charcot</td>
</tr>
<tr>
<td></td>
<td>Venous Doppler negative if only Charcot</td>
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</tbody>
</table>
Charcot Joint

Clinical Presentation Extremity

- Relatively painless
- Neurologic deficit
- Progressive
- May have adequate circulation
- Lack of protective sensation
- Microtrauma
- Ligamentous instability

Long Standing Charcot does not Guarantee Continued Adequate Blood Flow
Differential Diagnosis of Charcot Foot

- Osteomyelitis
- Cellulitis
- DVT
- Gout
- Septic Arthritis
- Pes planus
- Bone Tumor
- DJD

Osteomyelitis / Cellulitis more likely if there is an ulcer or history of an ulcer
Probe to Bone Test

Positive predictive value
53% - 95%

Negative predictive value
85% - 98%

Sensitivity 60% - 98%

Specificity 78% - 91%

May be more useful in excluding osteomyelitis than diagnosing it.

## IMAGING STRATEGIES

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-Ray</td>
<td>22-75%</td>
<td>53-80%</td>
</tr>
<tr>
<td>Tc 99 (TPBS)</td>
<td>50-100%</td>
<td>18-100%</td>
</tr>
<tr>
<td>In111 (Acute)</td>
<td>lower than Tc</td>
<td>Higher than Tc</td>
</tr>
<tr>
<td>In111 (Chronic)</td>
<td>60%</td>
<td>&gt; 50%</td>
</tr>
<tr>
<td>Ceretec</td>
<td>90%</td>
<td>86%</td>
</tr>
<tr>
<td>In111 + TPBS</td>
<td>100%</td>
<td>83%</td>
</tr>
<tr>
<td>MRI</td>
<td>90%</td>
<td>79%</td>
</tr>
</tbody>
</table>
PTB test combined with X-ray in diagnosing osteomyelitis

- 97% sensitivity
- 92% specificity
- Positive predictive value 97%
- Negative predictive value 93%

- Aragon-Sanchez et al, 2011
X-Rays
The 6 D’s

- Destruction
- Increased density
- Disorganization
- Dislocation
- Disarticulation
- Debris
“Arthropathy may precede the clinical onset of neurologic symptoms”

- Freiberg – like lesions
- Shortening of the proximal phalanx of the hallux
- Arthritic changes
- Ankylosis

HYPERTROPHIC – “OSTEOARTHRITIS WITH A VENGEANCE”

ATROPHIC – “SUCKED CANDY”
Patterns of Bone and Joint Destruction

- Forefoot:
  - IPJ, Phalanges, MTPJ, Distal MT bones

- Radiographs: Pencil like tapering of metatarsal bones with sucked in candy stick appearance.

- Plantar ulceration common finding.
  - Cofield and colleagues: 91%
  - Edmonds and colleagues: 93%
Patterns of Bone and Joint Destruction

Freiberg-like Lesions

Phalanx Shortening

Hypertrophic
Nuclear scans may be useful if...

- Diagnosis of infection uncertain
- Clinical presentation uncertain
- Extent of bone involvement uncertain
- Presence of implants precludes use of MRI or CT scans
- Documentation necessary
MRI

- With contrast
- Low signal intensity on T1 and T2 images within bone marrow space adjacent to involved joints
- Visualize abscess *(If Present)*
- Observe tendon and ligament complexes for future reconstruction
- Charcot versus osteomyelitis findings
Imaging Strategies

- X-ray first
- MRI best imaging option
- CT scan be useful when infection established and main concern is viability of underlying bone
- 3D CT Good for Reconstructive Planning
Charcot Joint Disease

**Invasive Procedures**

- Synovial Culture/Biopsy
  - Osteoarthritis vs Neuroarthropathy

- Bone Culture/Biopsy
  - Osteomyelitis vs Neuroarthropathy
Bone Biopsy  
Synovial Biopsy

Multiple shards of bone and soft tissue in the deep layers of synovium is pathognomonic for neuropathic osteoarthropathy.

Bone/Synovial Cultures

1. May rules in / out presence of infection
2. Speciates Organisms for Tx
Histology vs. Culture

- HISTOLOGY
  - Meyr study: 39 specimens, Unanimous agreement in only 33.33% of specimens.

- CULTURE
  - Possible Contamination
  - On Antibiotic?
  - Improper sampling
  - Stop antibiotic 48 hrs prior
Charcot
Eichenholtz Classification
Stage 0

- Joint edema
- Radiographs are negative
- Bone scan may be positive in all stages
Eichenholtz Classification
Stage 1: Developmental/Fragmentation

- Acute destructive period
  - Joint effusion
  - Soft tissue edema
  - Bone resorption
  - Dislocation/Subluxation
  - Increased joint mobility
  - Bone, cartilage debris
  - Intraarticular fractures
  - Fragmentation of bone

- NWB TCC
Eichenholtz Classification Stage 2: Coalescence

- Lessening of edema
- Absorption of fine debris
- Healing of fractures
- Fusion, coalescence
- Loss of vascularity
- Sclerosis of bone

- PWB TCC
- CROW
- Bivalved AFO
Eichenholtz Classification Stage 3: Reconstruction/Resolution

- Bone repair and remodelling
- Residual deformity
- Diminution of sclerosis
- Restoration of stability
- Increased bone density
- Exuberant ossification

- CMO with rocker soles
- CROW, Diabetic shoes
Sanders and Frykberg Classification

Zone 1: distal and proximal interphalangeal joints and metatarsophalangeal joints

Zone 2: tarsometatarsal joints (Lisfranc)

Zone 3: naviculo-cuneiform joints talo-navicular joint calcaneocuboid joint

Zone 4: ankle joint subtalar joint

Zone 5: calcaneus
Sanders and Frykberg Classification

Zone 1

Zone 2

Zone 3

Zone 4

Zone 5

Levels of involvement
Diabetic Charcot foot

10%

5%

30%

40%

- Ankle joint
- Calcaneus
- LisFranc - Tarsometatarsal joints
- Naviculocuneiform joints
- Talonavicular & Calcaneocuboid joints
- IPJs & phalanges
- MPJs & metatarsals

Ulceration
Patterns of Charcot (Sanders/Frykberg)

- MPJ/IPJ 15%
  - Ulcer MPJ/Toe

- Tarsal/Metatarsal 40%
  - Ulcer Styloid/Cuboid
Patterns of Charcot (Sanders/Frykberg)

Midtarsal joint 30%

Ulcer CC/Cuboid/Medial Arch (late)

Ankle 10%

Unstable Ulcer Head of Talus and Medial Malleolus
Patterns of Charcot (Sanders/Frykberg)

Calcaneus 5%
## NONOPERATIVE MANAGEMENT

<table>
<thead>
<tr>
<th>RESOLVE EDEMA</th>
<th>TERMINATE PROCESS</th>
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<tbody>
<tr>
<td>PROLONGED NWB CAST IMMOBILIZATION</td>
<td>PREVENT PROGRESSION</td>
</tr>
<tr>
<td>BRACING</td>
<td></td>
</tr>
<tr>
<td>ELECTRICAL BONE STIMULATION</td>
<td>STIMULATE BONE PRODUCTION</td>
</tr>
<tr>
<td>FOSEMAX, CALCITONIN</td>
<td>RETARD OSTEOCLASIS</td>
</tr>
<tr>
<td>SURGICAL INTERVENTION</td>
<td>MINOR OR MAJOR</td>
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</table>
Non Operative Protocols

- Standard BK cast
- Bivalved AFO walker
- CROW: Charcot Restraint Orthotic Walker
- PTB: Patellar Tendon Brace
Non Operative Management Goals

- Create and maintain plantigrade foot
- Heal ulcer
- Prevent infection
- Bony healing
- Prevention of deformity
Conservative Treatment

- **Treatment is prolonged and challenging**
  - Strict NWB 8-12 weeks (Brace, TCC, CROW)
  - Immobilization continued to consolidation stage.
  - Newer Options: Bisphosphonates, calcitonin, anti-inflammatory agents
  - Bone stimulators useful
    - Midfoot charcot: Keep immobilized 4-6 months
    - Ankle charcot: 9 months to 1 year
Surgical Intervention

- Controversy: When to intervene with surgery?
  - When bracing is ineffective and deformity may compromise skin by ulceration.
  - Unbraceable due to severe deformity

- Goals: Limb salvage and prevention of amputation.

- Avoid during Acute and Subacute stage
  - High risk of failure fixation and complications
PREOPERATIVE ESSENTIALS

- Stabilization of Diabetes
- Gait training for NWB status
- Prophylactic Bracing of contralateral limb
- Optimize local factors (edema, skin etc.)
- Know all surgical options
Considerations Prior to Surgery

• In Charcot foot with ulceration:
  • Must check for OM
    • Bone Biopsy
    • MRI, Ceretec scan
    • Plain films
    • CT scan to fully evaluate cross sectional anatomy prior to arthrodesis and reconstruction
<table>
<thead>
<tr>
<th>SOFT TISSUE</th>
<th>Tendoachilles Lengthening</th>
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<tbody>
<tr>
<td></td>
<td>Tendon Release or Transfer</td>
</tr>
<tr>
<td></td>
<td>Ulcer excision &amp; coverage</td>
</tr>
<tr>
<td>OSSEOUS</td>
<td>Relocation Osteotomy</td>
</tr>
<tr>
<td></td>
<td>Relocation Arthrodesis</td>
</tr>
<tr>
<td></td>
<td>Exostectomy</td>
</tr>
<tr>
<td></td>
<td>Reconstruction with Grafting</td>
</tr>
<tr>
<td>AMPUTATION</td>
<td>Partial, Segmental, Full</td>
</tr>
</tbody>
</table>
When to operate?

- Chronic ulceration
- Recurrent ulceration
- Joint instability
- Osteomyelitis
- Avascular Necrosis
- Pain
- Acute Fractures
Goals

- Restore stability
- Restore alignment
- Prepare for Bracing and appropriate shoe gear
- Prevent inevitable amputation
- Community Ambulation
Timing

Eichenholz Classification (Temporal)

If possible best done in Reconstruction Phase, Stage 3
## Impediments to repair…

<table>
<thead>
<tr>
<th>Soft Tissue Infection</th>
<th>Peripheral Vascular Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone Infection</td>
<td>Smoking</td>
</tr>
<tr>
<td>Uncontrolled Diabetes</td>
<td>Insufficient Bone Stock</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>Non-compliance</td>
</tr>
<tr>
<td>Eichenholz I</td>
<td></td>
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</tbody>
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Equinus

- 90% of DM with Charcot
- Major contributing factor to diabetic complications.
  - Increased plantar foot pressures
  - Ulcers
  - Instability at midfoot
- Weakness of anterior crural muscles
  - Drop foot gait
  - ↑ force of FF
  - Contracture triceps-surae from unopposed ankle DF
  - ↑ stress TMTJ, MTJ
Equinus....

Increased Plantar Foot Pressures

- 10 degrees required for proper gait
- If contracture identified can perform Tendo achilles lengthening
- Beware of over-lengthening can cause Calcaneal gait
Exostectomy

• **Stable Charcot Foot**
  
  • Recurrent ulceration.
  
  • Goal: Remove bony prominence predisposing to ulceration or difficulty with shoe gear.
  
  • Offloading procedure designed to accommodate deformities that are not amenable to WB or shoe gear.
Unstable CF or so severe that integrity of the foot is jeopardized

Key to success: adequate rigid fixation, whether internal or external.
Fixation Options

- Internal fixation (Locking Plates, Solid Screws)
- Intramedullary nail
- External fixation
- Blade Plate
- Staged and/or Combination of Fixation
- Beaming
Internal Fixation
External Fixation
Indications
External Fixation

- Open Fractures
- Comminuted Fractures
- Periarticular Fractures
- Osteomyelitis
- Deformity (length, angulation, rotation, translation, girth etc.)
- Soft tissue infection, Dead Space
- Soft tissue loss
Rationale of using Circular Multiplane External Fixator:

- Wound Stabilization
- Limb Stabilization
- Fixation Away From Diseased Bone
- Acute Shortening or Lengthening
- Correction of Deformity
- Static Fixation
- Bone Transport
Postoperative Protocol

3-5 months non-weightbearing
TCC x 2 months
Bracing x 12 months

Quality of Fusion
Activity level
Location of Fusion
Compliance
**Postoperative Bracing**

**MidFoot Deformity**
- In-Depth or Extra Depth Shoe
- Extended steel shank
- STS Insole
- Rocker Sole

**HindFoot Deformity**
- ...attach to double upright calf lacer or PTB AFO

**Significant Deformity**
- ...use whatever shoe or insert accommodates foot and attach to double upright brace
When Bad Things Happen....
Pearls

• Know your differentials.
• Be able to differentiate between OM and Charcot.
• Understand your diagnostic studies, know when to use them and what you’re looking for.
• Know when to use internal fixation versus external fixation and its indications.
• Know the indications for External fixation.
• Understand the principles of External fixation.
Thank You


• [Link](http://www.achm.org/index.php/General/Medicare-Accepted-Indications/Diabetic-Foot-Ulcer.html) American College of Hyperbaric Medicine. Diabetic Foot Ulcer Pathophysiology and Hyperbaric Effects