

New Concepts in Osteomyelitis Treatment with Long-term Outcomes

Jeffrey C. Karr DPM, CWS, ABLES, FAPWCA, FCCWS

Founder, Central Florida Limb Salvage Alliance
Chairman, Founder, The Osteomyelitis Center of Central Florida
Former Chairman: Institutional Review Board – Lakeland Regional Health (LRH)
Former Program Director: Center of Excellence - The Wound Care Center at LRH
Former Medical Director of Education and Research: The Wound Care Center at LRH



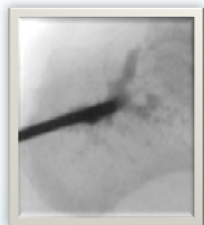
The Problem is Almost Solved–We Now Have A Carrier Vehicle That Is:

- **Absorbable** - does not require removal after surgery and releases all of the antibiotics
- **Isothermic**, able to utilize multiple antibiotics and antifungal drugs
- **Flowable** – To penetrate dysvascular and avascular bone allowing complete bacteria-drug interaction/contact
- **Flowable option**
- Significant **drug elution** with therapeutic drug **inhibitory levels** obtained



Percutaneous Antibiotic Delivery Technique (PAD-T)

- The PAD-T was pioneered by myself in 2009 as a safe, extremely effective means to deliver antibiotics into an area of bone infection with complete bone penetration and bactericidal contact with the adherent surface bacteria (biofilm)
- Indicated for acute or chronic osteomyelitis
- Antibiotic therapy for four weeks after this surgical procedure



Cierny-Mader Classification System

- Type 1: Medullary
- Type 2: Superficial
- Type 3: Localized
- Type 4: Diffuse

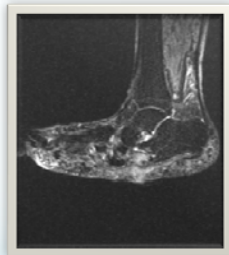


Cierny-Mader Classification System

- A-host: Normal system defenses, metabolic capacities, vascularity
- B-host: Local, systemic, or combined deficiencies
- C-host: High treatment morbidity, poor prognosis for positive outcome

Indications in Acute Osteomyelitis

- The PAD-T is indicated for osteomyelitis involving the Cierny Mader anatomical classification types I, II, and III in A or B host where there concern for traditional antibiotic failure secondary to risk factors such as DM, immune compromise, advanced PAD, ect.



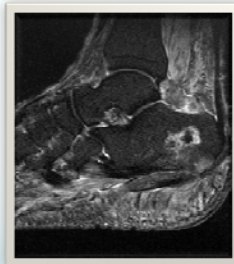
Indications in Acute Osteomyelitis

- The PAD-T is indicated in osteomyelitis cases involving medically compromised pediatric patients, adolescence patients, or an acute injury patient involving the Cierny-Mader anatomical classification types I, II, and III in A or B hosts.



Indications in Chronic Osteomyelitis

- The PAD-T is indicated for osteomyelitis involving the Cierny Mader anatomical classification types I, II, and III A or B host. Classification type IV in A or B host can be treated on a case-by-case basis.
- The PAD-T may be beneficial in type IV osteomyelitis when there is not significant loss of bone integrity



Indications in Chronic Osteomyelitis

- Spongiosa cavity defects up to a two to three cubic centimeters can be filled using the PAD-T and larger defects may have to be addressed through an open technique with possible external fixation



Pre-Operative Considerations

- A thorough familiarization of the three-dimensional anatomy of the area of osteomyelitis is paramount to successful percutaneous antibiotic delivery
- A tourniquet should be utilized to minimize medullary bleeding and bone venous return



Pre-Operative Considerations

- Only utilize antibiotics in powder form.
- Unless pre-operative culture results are available or drug allergies contradict their use, the antibiotics used are 1 gram of vancomycin and 1.2 grams of tobramycin with a 10 cc bone void filler kit.

Pre-Operative Considerations

Antibiotics Used

- Tobramycin
- Maxipime
- Vancomycin
- Zosyn
- Timentin (Flows Well)
- Fortaz (Expands/ gas bubbles)
- Cefazolin
- Rifampin
- Inipenim
- Cubacin
- PolyMyxin B

Antifungal/Yeast Used

- Voriconazole
- Amphotericin B

Pre-Operative Considerations

Accelerants

- Cefazolin
- Vancomycin
- Rifampin

Retardants

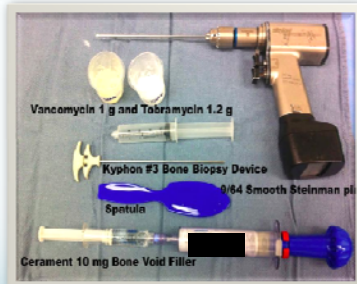
- Tobramycin
- Fortaz
- Timentin

Pre-Operative Considerations

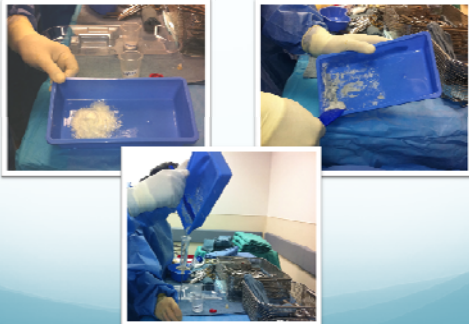
- Voriconazole is very sticky
- Amphotericin B works well



Intra-Operatively



Intra-Operatively



Percutaneous Antibiotics Delivery Technique

- A simple percutaneous skin incision can be completed near to the area of osteomyelitis.
- The bone cortex incision is made with a steinmann pin as close in diameter to the kyphon needle as possible to allow a snug purchase of the kyphon needle to the bone cortex to minimize BVF leakage.



Percutaneous Antibiotics Delivery Technique

- Under intra-operative fluoroscopy the kyphon needle is then advanced through the bone cortex incision into the spongiosa bone without far bone cortex violation.
- The kyphon needle is then slowly withdrawn under intra-operative fluoroscopy while delivering the BVF and antibiotics.



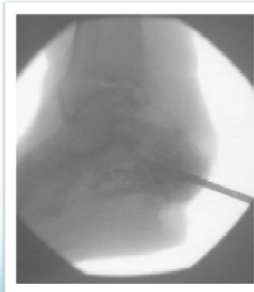
Percutaneous Antibiotics Delivery Technique

- Cultures and irrigation is completed through the bone cortex incision



Percutaneous Antibiotics Delivery Technique

- There should be a nice filling effect seen as the BVF and antibiotics are injected into the infected bone.
- Stop injecting when the bone defect is filled. This can be identified when you meet resistance in placing the product into the bone, there is product ooze through the bone cortex incision, small cortical defects, or some product is seen in the soft tissue or vasculature on intra-operative fluoroscopy





What Not To Do



Do Not Overfill



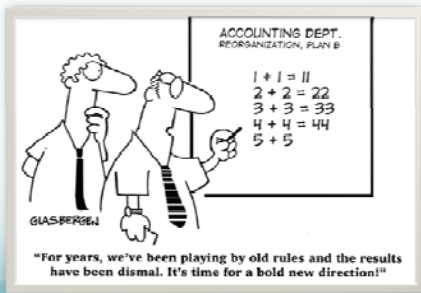
Do Not Overfill



Just Don't Do This



Human Clinical Outcomes



Seven-Year Retrospective Study

- 143 lower extremity infected bones in 125 patients were treated using the PAD-T with BVF and antibiotics. Infected bone locations were phalanx: 16, metatarsal: 36, cuneiform: 3, navicular: 4, cuboid: 8, calcaneus: 52, talus: 8, distal tibia: 13, and distal fibula: 3



Pending publication JAPMA July/August 2018

Seven-Year Retrospective Study - The Results

- Of the bone infection locations treated using the PAD-T with BVF and antibiotics there was a **96.15% success rate**.
- In working with the infectious disease doctors it was felt that antibiotics were only required for four weeks after this procedure unless otherwise clinically indicated.
- Follow-up was to seventy-four months

Seven-Year Retrospective Study - The Results

- Adverse events directly related to the PAD-T were absent.
- There were four patient deaths unrelated to the osteomyelitis treatment
- There was an additional nine below the knee amputations (BKA) due to the soft tissue infection and necrosis over whelming the body's ability to fight the disease process, unrelated to the osteomyelitis.

Seven-Year Retrospective Study - The Results

- There were five failures by bone location where bone resection was necessary.
- Classifying the bone failures by the Cierny-Mader classification system there were 3 stage III, 2 stage IV, and all 5 were B host.

The Bone Infection Unit, Oxford University Hospitals Foundation¹ - 2016

- 100 patients with chronic osteomyelitis, in 105 bones
- All patients were treated single-stage protocol including debridement dead space filling with the biocomposite and antibiotic
- Patients were followed up for a mean of 19.5 months (12 to 34). Infection was eradicated in 96 patients with a single procedure and all four recurrences were successfully managed with repeat surgery.

1. McNally MA et. al Bone Joint J 2016;98-B:1289-96.

The Bone Infection Unit, Oxford University Hospitals Foundation¹ - 2016

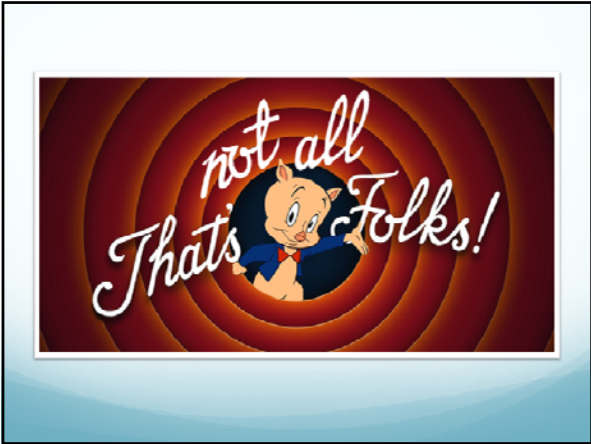
- Adverse events were uncommon, with three fractures, six wound leaks and three unrelated deaths.
- Outcome was not dependent on C-M host class, microbial culture, wound leakage or presence of nonunion.

1. McNally MA et. al Bone Joint J 2016;98-B:1289-96.

Single stage treatment of diabetic calcaneal osteomyelitis with an absorbable gentamicin-loaded calcium sulphate/hydroxyapatite biocomposite¹

- Debridement of the dead bone and local delivery of antibiotic in drilled tunnels using antibiotic-loaded absorbable calcium sulphate/hydroxyapatite biocomposite.
- Twelve consecutive diabetic patients with heel ulcers and calcaneal osteomyelitis were treated
- Infection was eradicated in all 12 patients with a single stage procedure

1. Drampolis et. al. The Foot 34 (2018) 40-44.



Antibiotic Carrier Vehicles – Ceramic Limitations - Leakage?

- As the BVF leaks out of the bone if the BVF is unable to maintain surface contact with the dysvascular and avascular bone to allow complete bacteria-drug interaction/contact
- In a study in patients who had a forefoot amputation for osteomyelitis, The overall rate of residual osteomyelitis was 40.7%¹

1. Atway S et al., The Journal of Foot & Ankle Surgery 51 (2012) 749–752

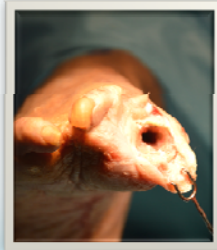
The Leakage Solution – Novogro Putty

- Carboxymethyl cellulose (CMC), a biocompatible and biodegradable sugar-based polymer combined with a calcium phosphate-based cement (CPC)¹
- Can use any antibiotic in powder form

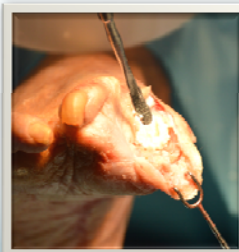
Release Time (Days)	MW 25K (%)	MW 50K (%)	MW 75K (%)
0	0	0	0
5	~15	~25	~35
10	~30	~45	~60
15	~40	~60	~75
20	~50	~70	~80
25	~55	~75	~80

1. Lin B et. al SURGICAL INFECTIONS Volume 18, Number 2, 2017

Avoiding the Flowable BVF Leakage



Avoiding the Flowable BVF Leakage



Avoiding the Flowable BVF Leakage



Conclusions

- PAD-T is a percutaneous, minimally invasive procedure for drug delivery with an absorbable BVF
- No antibiotic class restriction - isothermic reaction
- Flowable, direct antibiotic delivery to the area of osteomyelitis with inhibitory antibacterial levels achieved
- *In vitro*, elusion, and seven year human data available with these outcomes reproduced by Drampolis et al and McNally et al.
- Alternative available for flowable BVF leakage

www.osteomyelitiscenter.com

Thank You

