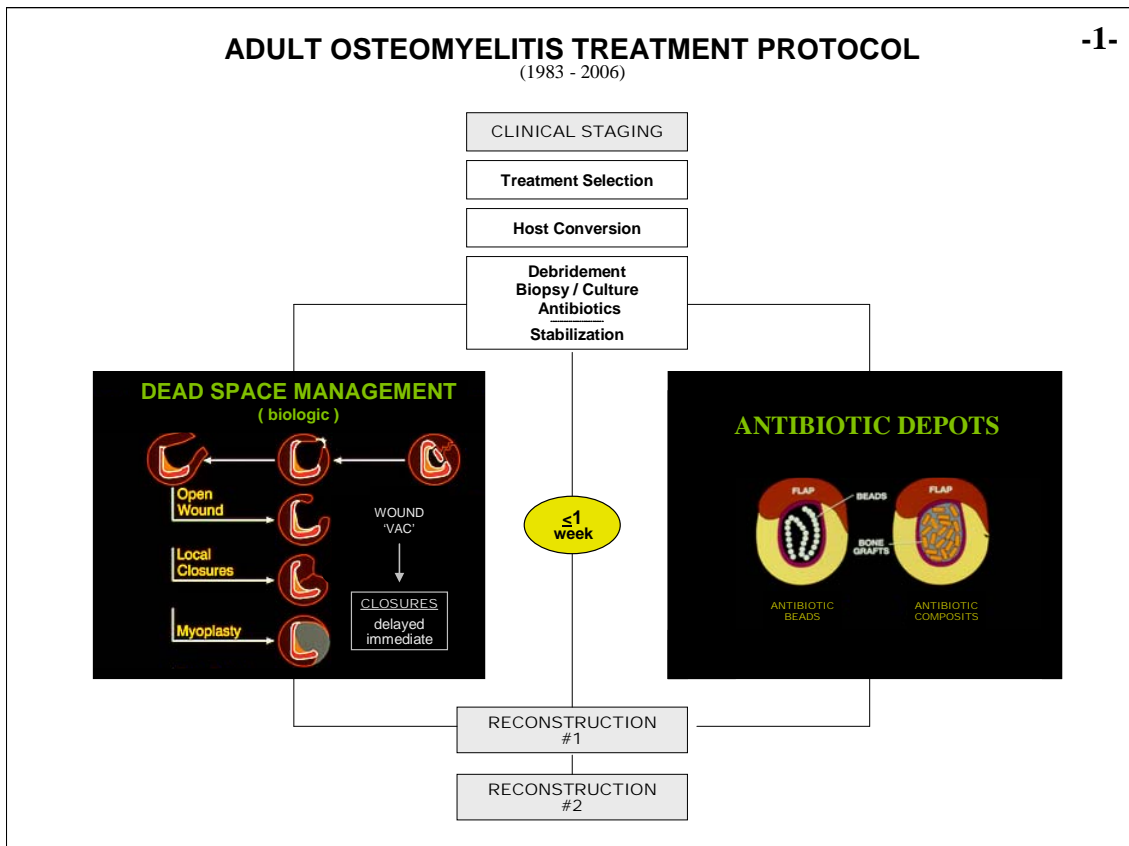


ADULT OSTEOMYELITIS PROTOCOL (San Diego – 2006)

In the last 25 years, over 3,000 patients with refractory long bone infections have entered our prospective studies to assess the anatomic and the physiologic parameters of adult osteomyelitis. Patient selection has been based on the Cierny/Mader, *Clinical Staging System for Adult Osteomyelitis*. In this system, four factors are used to align treatment with a realistic prognosis: the site of the infection, the extent of the disease, the condition of the host, and functional goals (see OSTEOMYELITIS).



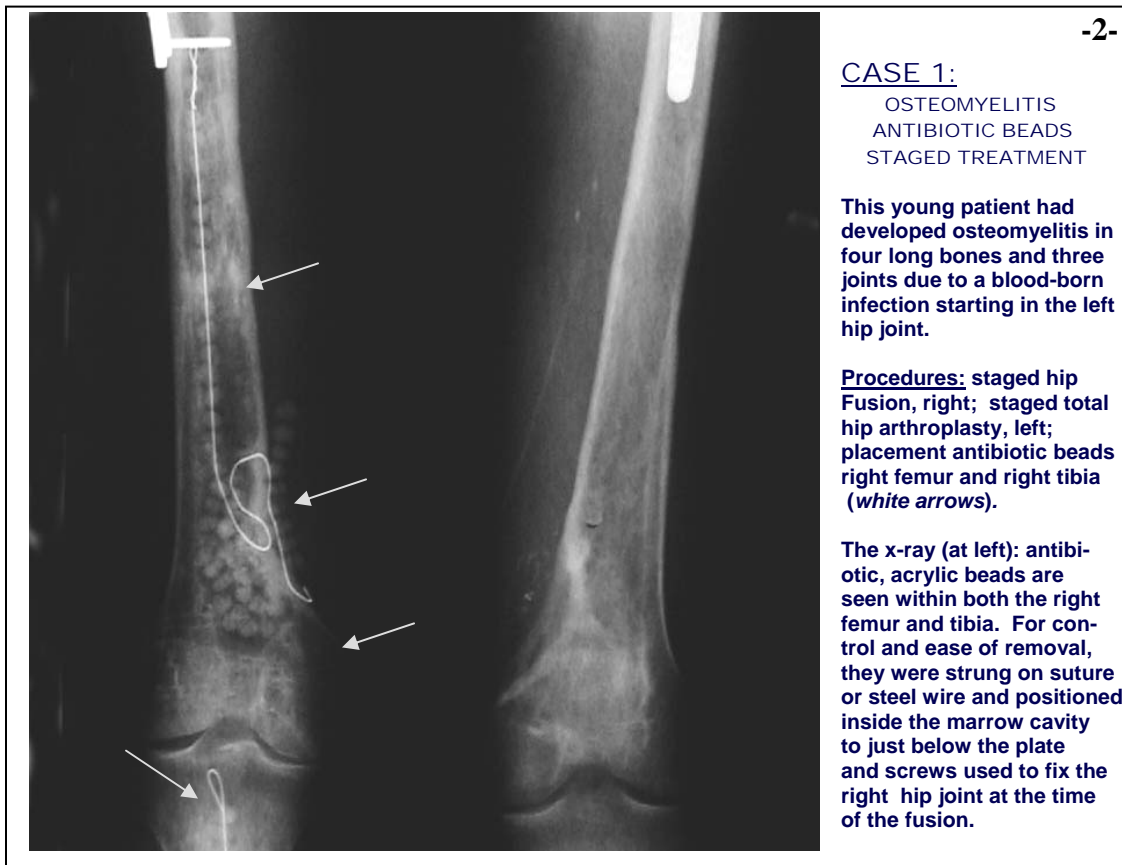
There are three treatment formats: limb salvage, amputation or palliation. To maximize outcomes (*host rescue*), host factors that will negatively affect treatment and wound healing (co-morbidities) are amended, beforehand. At surgery, all diseased tissue, foreign bodies and surgical implants are excised. Systemic antibiotics are initiated after biopsies are sent for culture and histologic evaluation. The wound is then flushed with clean fluids and assessed for closure.

Antibiotics are the mainstay of treatment of acute compared with chronic osteomyelitis which requires a staged approach: initial clearance then followed by reconstruction.

Antibiotic Depots: BEADS, SPACERS, GELS, PROSTALAC JOINTS

Following debridement, most wounds were, until recently, left 'open' to either heal spontaneously or undergo a 'delayed' closure, when safe and the risk for infection was low. In **1983**, wound care was greatly facilitated with the introduction of locally-implanted, antibiotic depots. First, came the use of antibiotic-impregnated, acrylic bone cements in the salvage of infected total joint arthroplasties. Later, these cements were modified for implantation into debrided wounds in the form of 7.0mm beads; the high surface-to-volume ratio of the beads favored high, prolonged elution rates and local antibiotic concentrations 50x to 100x higher than ever achieved, previously. When used in conjunction with systemic therapy and a thorough debridement, antibiotic beads could render the wounds clean and ready for reconstruction reliably and quickly (weeks). *For the first time in medical history, it was safe to close an infected wound right after its debridement.*

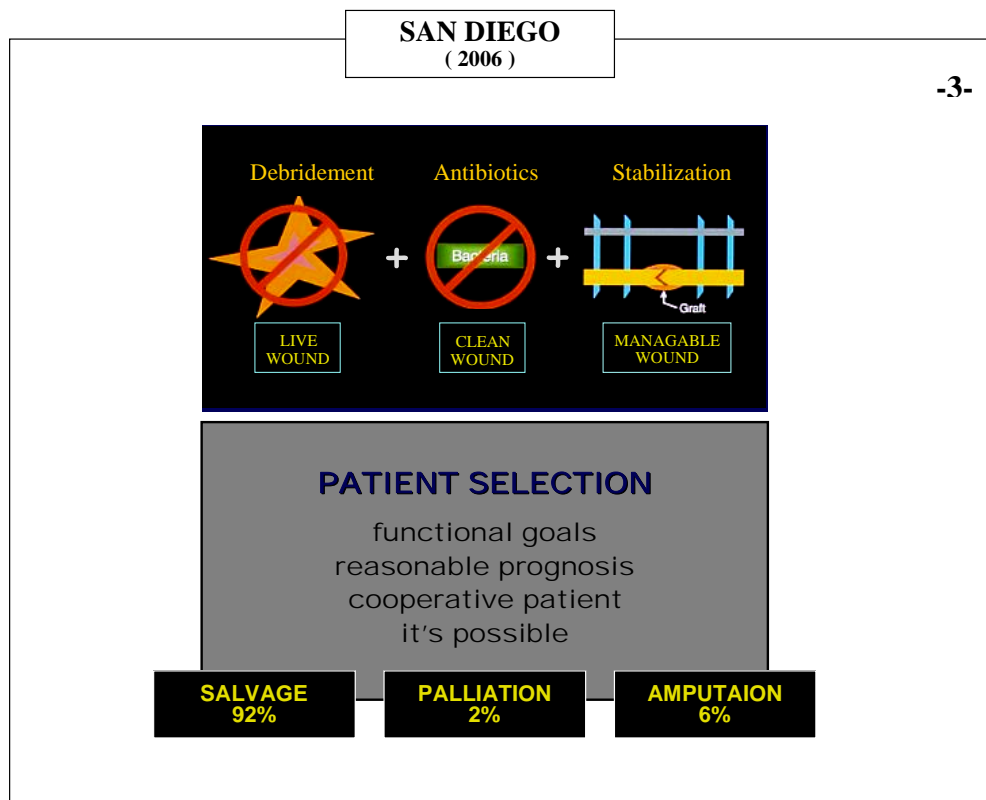
With time, the morbidity of treatment dropped, precipitately and limb salvage became available to many, who, until that time, heard only "amputation" from care givers. By **1998**, less than 4% of our patients left the surgery suite with an open wound and patients were discharged in days rather than weeks. The duration of systemic antibiotic therapy dropped below 2 weeks in 9 out of 10 protocols and the success rates increased, steadily, with time and experience.



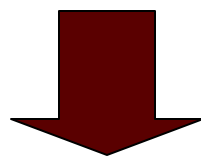
Staged protocols: OPEN FRACTURES, INFECTED NON-UNION, TOTAL JOINT INFECTIONS.

By 1986, our research on 364 consecutive patients confirmed the hypothesis: *“following a thorough wound debridement, antibiotic beads will reliably convert an infected wound to a clean wound.”* By 1994, two-stage protocols were a reality: antibiotic beads were implanted into wounds following debridement and coverage; reconstruction was performed one to 6 months later using “clean wound” constructs. The methods were expanded to include the treatment of open fractures, infected fractures, infected non-unions and peri-prosthetic total joint infections. New depot devices were gradually introduced to facilitate care and improve the quality of life for those undergoing treatment: block-spacers, bio-degradable beads, smart-gels, fiber-metals, and whole prosthetic joints made from impregnated materials (articulated spacers).

Reconstruction: With success rates as high as 95%, there were fewer amputations (*figure 3*) and more options to consider for salvage: bone transplants (allografts), deformity correction, limb lengthening (see, ILIZAROV), whole-bone replacements, mega-prosthetic total-joint arthroplasties.



Treatment of Chronic Infection. Cierny III,G, DiPasquale, D; in symposium, *Extremity War Injuries: State of the Art and Future Directions.*: JAAOS; Vol. 14, No. 10, pp105-110, 2006.



ADULT CHRONIC OSTEOMYELITIS

(San Diego Treatment Algorithm; 2010)

- I. PATIENT EVALUATION
- II. PRE-OP TESTING
 - laboratory testing: full metabolic panel, CBC with differential, coagulation panel, UA, ESR, CRP, colonization testing
 - diagnostics: vascular indices; ultra-sound; oxygen tensions (T_cPO₂)
 - radiology: plain films; MRI, CT, Nuclear, PET Scans; angiography studies
 - tissue specimens: cultures; histology sections; PCR pyrosequencing
- III. CLINICAL STAGING
 - anatomic type: I-medullary; II-superficial; III-localized; IV-diffuse
 - physiologic class: A-host; B-host; C-host
- IV. TREATMENT FORMAT
 - limb salvage
 - amputation
 - palliation C-hosts; no 'treatment for cure'
- V. HOST OPTIMIZATION: reverse amenable co-morbidities
- VI. 1st SURGERY
 - (A) one-stage treatment:
 1. debridement/ tissue specimens/ antibiotics (*all treatment formats*)
 2. dead space management (*limb-salvage, amputation*)
 - wound: secondary intention; primary vs delayed closures
 - bone: vascularized bone flaps; acute shortening
 - fixation: orthotics; external fixators
 - depots: antibiotic-beads¹
 - (B) 1st of multi-stage treatments:
 1. debridement/ tissue specimens/ systemic antibiotics
 2. **DOUBLE SET UP**:^(46,68) *change instruments, re-prep and -drape, new gowns/gloves*
 3. temporary fixation: external fixation; antibiotic-coated hardware
 4. dead space management:
 - wound: secondary intention; primary vs delayed closures
 - bone: bone transport;^(54,69 -71) vascularized bone flaps
 - fixation: orthotics; external fixators; hardware (coated)*
 - depots: antibiotic-beads, -spacers
- VII. OUT PATIENT FOLLOW UP: wound surveillance; labs (ESR /CRP); phys. rehabilitation
- VIII. 2nd SURGERY (second stage)
 - (A) definitive reconstruction:
 1. prophylactic antibiotics/ hardware removal/ debridement/ tissue specimens
(frozen biopsy negative – no, inflammation)
 2. **DOUBLE SET UP**: *change instruments, re-prep and -drape, new gowns/gloves*
 3. reconstruction:
 - wound: primary closure
 - bone: bone grafts, vascularized bone-flaps, prosthetic joints
 - fixation: orthotics; external or internal fixation, prosthetic joints
 - depots: antibiotic-beads, permanent spacers, hardware(coated)*

- (B) staged reconstruction #2:
 - 1. prophylactic antibiotics/ hardware removal/ debridement/ tissue specimens
(frozen biopsy positive – acute inflammation)
 - 2. VI B (above) vs amputation
- IX. OUT PATIENT FOLLOW UP: wound surveillance; labs (ESR /CRP); phys. rehabilitation_
- X. 3rd SURGERY (third stage)
 - A) definitive reconstruction: **(frozen biopsy negative – no, inflammation)**
 - 1. VIII A (above)
 - B) staged reconstruction #3: **(frozen biopsy positive – acute inflammation)**
 - 1. VI B (above) vs amputation
- XI. 4th SURGERY: biologic reconstructions** (no hardware, no foreign bodies)
- XII. OUT PATIENT FOLLOW UP: wound surveillance; labs (ESR /CRP); phys. rehabilitation

Patients entering a palliation protocol and/or not requiring reconstruction following debridement complete their format after a single debridement (VI,A,2). Segmental reconstructions and the use of surgical implants are staged to follow interval treatment with a local antibiotic-depot. All specimens are cultured, examined histologically and undergo quantitative-PCR pyrosequencing. ***hardware(coated):** a medullary rod, cortical plate or prosthesis coated with antibiotic-impregnated bone cement; **biologic reconstructions**:** bypass synostoses, acute shortenings, bone transport, resection arthroplasties, etc.

- modified from Cierny G III, DiPasquale D: Adult Osteomyelitis; (eds) Cierny GIII, McLaren AC, Wongworawat MD: *Orthopaedic Knowledge Update: Musculoskeletal Infection*. Rosemont, IL, American Academy of Orthopaedic Surgeons, 2009, pp 135-153.