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QUESTION 2: Is there a minimum number of complex osteomyelitis procedures a surgeon should perform annually to ensure proper outcomes?

RECOMMENDATION: There is no literature supporting a minimum number of complex osteomyelitis procedures a surgeon should perform annually to ensure proper outcomes. Higher-volume referral centers, centers of excellence and multidisciplinary teams for the treatment of complex osteomyelitis may result in improved outcomes.

LEVEL OF EVIDENCE: Consensus

DELEGATE VOTE: Agree: 76%, Disagree: 14%, Abstain: 10% (Super Majority, Strong Consensus)

RATIONALE

In the literature reviewed, there is no evidence to answer the question. Osteomyelitis is a complex pathology, which needs years of follow-up to be able to demonstrate the sustained remission of the disease. Osteomyelitis has multiple etiologies: 19% hematogenous, 47% secondary to a contiguous focus and 34 % due to vascular insufficiency [1]. There is no evidence to establish the optimal duration of treatment and many studies do not present good-quality data and include a small number of patients [1,2]. Therefore, most of the recommendations for the treatment of osteomyelitis is based on expert opinions.

In joint arthroplasty, high-volume centers, multidisciplinary teams and centers of excellence have been shown to improve patient outcomes with respect to the treatment of prosthetic joint infections [3]. In trauma, there have been few studies looking at the benefit of high-volume centers for the treatment of complex osteomyelitis and septic nonunions. Bauer et al. retrospectively evaluated the results of a French referral center for complex bone infections. They had 55 patients over the course of 10 years who were treated for infected non-unions of the tibia or femur. They showed that 89% of patients with an infected tibial or femoral non-union treated by a team specialized in complex bone and joint infections using a standardized surgical protocol had bone union and healing of the infection in an average of nine months [4]. In a similar study, Bose et al. reported on 67 long bone infected non-unions over 6 years treated by a multidisciplinary team. They found that 59/67 (88%) went on to fracture union and eradication of their infection [5]. Lastly, Salvana et al. treated 82 patients over 7 years with chronic osteomyelitis with an integrated team approach and found successful union and limb salvage in 77 (94%) cases [6]. In these three studies, the centers treated on average 6-12 cases of complex osteomyelitis per year. At this time there is no data supporting a minimum number of cases of complex osteomyelitis a surgeon should perform annually to ensure good results, but having greater experience collectively at an institution or within a dedicated unit would presumably results in the greatest likelihood of a successful outcome in this difficult cohort of patients.

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QUESTION 3: Who are the essential members of the multidisciplinary team required to manage infected fractures and non-unions?

RECOMMENDATION: The essential members of the multidisciplinary team managing infected fractures and non-unions require expertise in bone reconstruction, soft tissue reconstruction, microbiology, antibiotic treatment and advanced imaging. It is important to note that the exact members of the group and other specialists required will eventually depend on patient needs and local preferences.

LEVEL OF EVIDENCE: Consensus

DELEGATE VOTE: Agree: 100%, Disagree: 0%, Abstain: 0% (Unanimous, Strongest Consensus)

RATIONALE

There is increasing evidence that teamwork and collaboration among healthcare workers are essential to improving patient outcomes [1,2]. Therefore, it is important to implement a multidisciplinary approach in treatment algorithms of fracture-related infec-

tions (FRI). The use of an antibiotic stewardship program is already a well-known concept for the management of different infection-related entities. These are defined as coordinated interventions designed to improve and measure the appropriate use of antibiotic agents by promoting selection of the optimal regimen, including dosing, duration of therapy and route of administration [3]. With its multidisciplinary approach, an antibiotic stewardship program improves patient safety and outcomes, and when combined with reduced readmission rates, reduces healthcare costs without compromising the quality of care [4–6]. Rodriguez et al. evaluated an evidence-based protocol for antibiotic prophylaxis in open fractures [7]. They demonstrated a short course of narrow-spectrum antibiotics (avoiding the use of broad-spectrum aminoglycosides and glycopeptides) does not increase the risk of soft tissue and skin infections after an open fracture.

Following the Infectious Diseases Society of America guidelines, infectious disease (ID) physicians and clinical pharmacists are the core members of antibiotic stewardship programs, but microbiologists and the implementation of administrative and information technology can also be of great importance [8]. However, as recently stated by Pulcini et al. [9], the composition of these teams is flexible and should be based on existing international recommendations and adapted to the local context based on resources available. Regarding the multidisciplinary approach to FRI, the treatment is based on two pillars: surgical management and clinical management.

Where the surgical management plays an important role, it seems imperative that surgeons (including musculoskeletal trauma surgeons and plastic surgeons) act as central members. Nevertheless, studies within this field are scarce. A multidisciplinary approach, which is constituted of collaboration between musculoskeletal trauma surgeons, the hospital's infection control department, nurses and anesthesiologists as primary team members, has been described to guide FRI prevention strategies [8].

With respect to treatment of FRI, a recent systematic review by Bezstarosti et al. (unpublished data) showed that out of the 93 included studies conducted between 1990 and 2017, only 12 studies (13%) discussed the members that were involved in their multidisciplinary team, with a wide variety of team members available: musculoskeletal trauma surgeons (10 studies), plastic surgeons (5 studies), ID physicians (5 studies), pharmacists (1 study), radiologists (1 study) and not further specified members (3 studies) [10–21]. A study by Bose et al. [12] obtained good results with a multidisciplinary team comprised of orthopaedic surgeons, plastic surgeons, radiologists and ID physicians for treating patients with infected nonunions of long bones [12]. It is important to note that most of the above-mentioned treatment studies focused on chronic/late FRI patients. A study by Dudareva et al. [22] reported a multidisciplinary approach allowed for successful treatment in the majority of cases with osteomyelitis of pelvic bones. The team members in this study were comprised of orthopaedic surgeons, plastic surgeons, and ID physicians. The team was completed by the contribution of specialized nurses, physiotherapists, occupational therapists and musculoskeletal radiologists.

In conclusion, although data specifically focusing on FRI is scarce, a collaboration of different specialties most likely would improve the outcomes in this difficult patient population. No study has evaluated the specific essential participants, but do mention the results with involved members. Antibiotic stewardship programs have already proven their use by means of a multidisciplinary collaboration between ID specialists, clinical pharmacists and microbiologists. The same approach should be applied to set up a main treatment plan for the FRI patient, including surgical, antibiotic and clinical aspects.

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