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QUESTION 2: What antibiotic(s) should be used for low-energy open fractures? What antibiotic(s) should be used for high-energy open and grossly-contaminated fractures?

RECOMMENDATION:

1. Antibiotic treatment targeting gram-positive organisms is recommended as soon as possible for all open fractures; low- and high-energy.
2. In high-energy or grossly-contaminated open fractures, additional antibiotics should be considered for gram-negative coverage.

LEVEL OF EVIDENCE: 1. Strong; 2. Limited

DELEGATE VOTE: Agree: 95%, Disagree: 0%, Abstain: 5% (Unanimous, Strongest Consensus)

RATIONALE

Open fractures are those that occur with associated skin and overlying soft tissue disruption, resulting in communication between the fracture site and the external environment [1]. The amount of energy imparted to an extremity during trauma results in a greater or lesser degree of bone and soft tissue compromise. Many authors have attempted to use different classifications to correlate the degree or amount of energy and the tissue compromise. The most commonly used is one described by Anderson et al. [2], later modified by Gustilo et al. [3]. For the purpose of this document, this definition will be used and correlated with the degree of energy associated. According to this classification, type I fractures are characterized by a wound of < 1 cm with minimal contamination, comminution and soft-tissue damage (these are low-energy). Type II features lacerations of > 1 cm and moderate soft-tissue injury, but wound coverage is adequate and periosteal stripping is not extensive (moderate energy). Type III fractures are divided into three subtypes and are all considered as high-energy. Type IIIA is characterized by high-energy trauma, extensive soft-tissue damage and substantial contamination, but wound coverage remains adequate after debridement has been completed. Type IIIB displays inadequate wound coverage following debridement and coverage procedures are required. Type IIIC is an open fracture associated with an arterial injury requiring repair.

One of the main purposes of this classification, besides description, is the correlation with infection rates which have been shown to increase correspondingly [4]. Rates of infection have been reported to range from 0% to 2% for type I, 2% to 5% for type II, 5% to 10% for type IIIA, 10% to 50% for type IIIB, and 25% to 60% for type IIIC3 [2,3,5]. Prophylactic antibiotics have become a standard for open fractures since 1974 when Patzakis et al. [6] demonstrated in his prospective study that cephalothin had significantly lowered the infection rate to 2.3% compared with 13.9% in the control group. This finding was later confirmed by a systematic review demonstrating that the use of antibiotics had a protective effect against early infection compared with no antibiotics or placebo [7].

The efficacy of first-generation cephalosporins for open fractures has been confirmed in level I and II studies [7,8]. As initially reported by Gustilo et al. [3], type III fractures had a high rate of gram-negative infections, which supports the addition of an aminoglycoside or a third-generation cephalosporin. A different, prospective randomized study of severe open tibia fractures (type II and III) comparing

first-generation cephalosporin and third-generation cephalosporin showed no statistical difference in the rate of infection [9]. *The Surgical Infection Society Guideline: Prophylactic Antibiotic Use in Open Fractures: an Evidence-Based Guideline* recommends the administration of first-generation cephalosporin for 24-48 hours preoperatively as a safe and effective prophylactic choice in patients with type I open fractures [10]. The *East Practice Management Guidelines Work Group: Update to Practice Management Guidelines for Prophylactic Antibiotic Use in Open Fractures* recommends that preoperative antibiotic prophylaxis for coverage of gram-positive organisms should begin for patients with open fractures as soon as possible after injury [11]. For type III fractures, additional coverage for gram-negative organisms may be given as these fractures are considered highly contaminated, although this aspect is not yet clearly supported by high-level studies [12].

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