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QUESTION 2: What diagnostic criteria must be fulfilled to diagnose surgical site infection (SSI) or fracture related infection (FRI) in orthopaedic trauma (including external fixators)?

RECOMMENDATION: Diagnostic criteria proposed by the International Consensus Group on FRI (published in 2017) should be used to diagnose infection in fracture cases. In cases, more than four weeks from fracture, histological confirmation of > 5 neutrophils per high power field is confirmatory of infection.

LEVEL OF EVIDENCE: Consensus

DELEGATE VOTE: Agree: 85%, Disagree: 5%, Abstain: 10% (Super Majority, Strong Consensus)

RATIONALE

Unlike periprosthetic joint infections (PJI) which have clearly-defined diagnostic criteria [1], infection associated with orthopaedic trauma procedures does not. Orthopaedic trauma has a higher rate of SSIs compared to other surgical specialties, yet it lacks an infection definition agreement [2–4]. This is likely due to the great variety and complexity of skeletal trauma and variability of surgical procedures. According to the initial Centers for Disease Control and Prevention (CDC) definition of SSI in trauma, this could occur up to one year following surgery [5]. However, in their last revision, this time period has been reduced to 90 days [6]. This poses a challenge for diagnosis, since infections related to orthopaedic trauma are often subclinical and some only display pain without any other signs or symptoms [5,7]. Furthermore, the CDC guidelines distinguish between superficial incisional, deep incisional and organ/space infections. Bonnevialle et al. already stated that the term "superficial infection" is at best arbitrary [8], and poses particularly challenging problems in infection associated with orthopaedic trauma. Finally, in orthopaedic trauma research, these terms (e.g., superficial and deep) are often used inaccurately or inappropriately, which makes comparison of literature difficult [9]. In the current clinical literature, numerous terms other than SSI are used with respect to infections associated with orthopedic trauma procedures (e.g., posttraumatic osteomyelitis, osteitis). Often, no distinction is made between the terms osteitis and osteomyelitis. Overall, these terms seem not useful as the main issue is the presence of bacteria at the fracture site and around the implant, rather than the semantics of the pathogenesis of the infection [9].

Orthopaedic trauma surgeons realized that the definition for PJI, criteria for osteomyelitis and the CDC guidelines could not be easily extrapolated to fracture cases, and, therefore, a definition had to be developed. This was recently confirmed by an international survey for registered AOTrauma users. In this survey, surgeons were asked about the need for a working definition, and 90% of more than 2,000 surgeons who responded suggested that a definition solely focusing on infection in orthopaedic trauma (i.e., fractures) was required [10]. Therefore, a special effort was made, with the support of multipele orginazations, to develop (AO Foundation and European Bone and Joint Infection Society (EBJIS)) [9] and update (AO Foundation, Orthopaedic Trauma Association (OTA), EBJIS and PRO-Implant Foundation) [11] a consensus definition. The consensus group designated infection related to orthopaedic trauma (i.e., fractures) as FRIs and established a definition based on two different kinds of diagnostic criteria: confirmatory (infection definitely present if a confirmatory criterion is met) or suggestive (features associated with infection and requiring further investigation) criteria (Table 1).

Without question this consensus definition should be validated by prospective data collection in order to gather evidence of its use in clinical studies and to prove that it can become a valuable tool in comparative research.

TABLE 1. Criteria to define FRI

Confirmatory Criteria	Suggestive Criteria
1. Fistula, sinus or wound breakdown.	1. Clinical signs: pain increasing over time, local redness, local swelling, increased local temperature or fever.
2. Purulent drainage or presence of pus.	2. Radiological and nuclear imaging signs
3. Phenotypically indistinguishable pathogens identified by culture from at least two separate deep tissue/implant specimens.	3. Pathogenic organism identified by culture from a single deep tissue/implant specimen.
4. Presence of more than five polymorphonuclear neutrophil per high power field, confirmed by histopathological examination [12].	4. Elevated serum inflammatory markers: ESR, WBC, CRP
	5. Persistent or increasing wound drainage.
	6. New-onset of joint effusion in fracture patients.

FRI, fracture-related infection; ESR, erythrocyte sedimentation rate; CRP, C-reactive protein; WBC, white blood cell

External Fixation

The infection rates reported with the use of external fixators are higher than with osteosynthesis with an incidence of infection of up to 71% [13]. However, there is also no clarity in regards to the diagnosis of SSI in external fixation. There are two classification systems, Checketts-Otterburn and Sims, neither of which have been validated [13,14]. The most commonly used is the Checketts-Otterburn schema, which describes clinical signs such as redness, discharge, pain, edema, radiological changes in the screw-bone interface and compromise in several levels [15].

In conclusion, there is a scarcity of scientific evidence regarding diagnostic criteria to define SSIs in orthopaedic trauma. The CDC published guidelines for SSIs, which distinguish between superficial incisional, deep incisional and organ/space infections, seem not suitable to define/diagnose infection in orthopaedic trauma patients. The recently published, and thereafter updated, international consensus definition seems an adequate replacement. This definition introduces, instead of SSI, the term FRI. Furthermore, two levels of certainty around the diagnostic features are defined. Criteria can be confirmatory (infection definitely present if a confirmatory criterion is met) or suggestive. This definition should be validated by prospective data in the future.

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QUESTION 3: What diagnostic criteria define infected non-union of long bone?

RECOMMENDATION: The lack of scientific evidence precludes the development of diagnostic criteria that are solely based on sound evidence. The combination of the consensus definition of fracture-related infection (FRI) with a nonunion is a reasonable starting place, however definitions of nonunion vary and both the FRI definition and any proposed criteria for long bone nonunion will need scientific validation.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 86%, Disagree: 9%, Abstain: 5% (Super Majority, Strong Consensus)

RATIONALE

Introduction

FRI is a feared musculoskeletal complication and one of the most challenging in trauma surgery. Currently, estimating the impact of FRI has been hampered by the lack of a clear definition [1,2]. Interestingly, this issue was previously raised in an Arbeitsgemeinschaft Osteosynthesefragen/Association for the Study of Internal Fixation (AO/ASIF) scientific supplement publication by Arens et al. in 1996, wherein the authors stated in a combined clinical and experimental study on FRI, "It is astonishing that in all papers in which infection is mentioned, the term 'infection' is not defined" [3]. In fact, this was confirmed by a recent systematic review, which showed that only a minority of randomized controlled trials (2%) in fracture cares use any kind of standardized definition of FRI [4]. The lack of a clear definition of FRI mirrors the situation for prosthetic joint infection (PJI) identified many years ago [1–5]. The situation for PJI [6] and diabetic foot infection, for example [7], has improved with consensus definitions emerging in recent years. Orthopaedic trauma surgeons realized that neither the definition for PJI nor the Centers for Disease Control and Prevention (CDC) guidelines could be easily extrapolated to fracture cases and that a definition for FRI had to be developed.

This was recently confirmed by an international survey for registered AOTrauma users. In this survey, surgeons were asked about the need for a working definition of FRI and 90% of more than