Prevention

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QUESTION 1: What are the optimal prophylactic perioperative antibiotics for patients undergoing total elbow arthroplasty (TEA)?

RECOMMENDATION: Patients undergoing primary TEA should receive antibiotics that cover gram-positive and gram-negative organisms specific to the regionally encountered organisms. Peer-reviewed literature supports that cefazolin should be dosed based on body weight. Patients with methicillin-resistant *Staphylococcus aureus* (*S. aureus*) colonization should receive weight-based glycopeptide, preferably in combination with cefazolin. Patients with a true hypersensitivity reaction or adverse reaction that precludes the use of cefazolin should receive vancomycin or clindamycin.

LEVEL OF EVIDENCE: Consensus

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

RATIONALE

A comprehensive literature search of three online databases (PubMed/Medline, Google Scholar and Embase) was performed using the following MeSH search terms: "elbow," "elbow joint," "joint prosthesis," "arthroplasty" and "replacement."

Because of the evolution of TEA techniques, only articles from the last 10 years were selected, published from January 2008 until January 2018. On the basis of the titles and abstracts, two reviewers independently identified potentially relevant articles for review of the full text. The reference lists of the included articles were manually checked to avoid missing relevant articles. When the full text was obtained, the authors independently selected articles. Studies were not blinded for author, affiliation or source.

Inclusion and Exclusion Criteria

The included articles presented original data on patients who had undergone TEA. The diagnoses included the following indications: osteoarthritis, trauma/fracture, post-traumatic osteoarthritis, rheumatoid arthritis, hemophilia and other inflammatory diseases. Studies with a minimum duration of follow-up of two years and a minimum of 10 patients were included. Studies on revision operations were not included. Articles presenting the results of both revision and primary TEA were excluded unless the information for primary TEA could be extracted. Articles presenting the results for interposition arthroplasties, fully-hinged prostheses, hemiarthroplasty or partial resurfacing of the elbow were excluded. Review articles, expert opinions and surgical technique articles were excluded. When possible, studies comparing different groups were analyzed separately. The search was restricted to articles written in English. Some articles that represented institutional historical databases were included only once.

Data Extraction

After the initial assessment for inclusion, two reviewers extracted data from the included articles. The primary goal was to determine the rate of infection after TEA and the pathogen responsible to determine which is potentially the best antibiotic regimen.

The following parameters were recorded when available: numbers of patients and elbows, design of TEA implant, indication for TEA (e.g., primary osteoarthritis, rheumatoid arthritis, fracture, post-traumatic osteoarthritis or other abnormality), whether the prosthesis was linked or unlinked, the rate of infection and the pathogen responsible for the infection (known/unknown, single/multibacterial). When prophylactic antibiotics were reported, they were recorded. No other attempt was made to extract other data regarding other complications.

Data and Statistical Analysis

Different groups were established on the basis of the preoperative regimen and the causative pathogen, when known. The outcome measures were the rate of infection and the distribution according to the pathogen. When sensitivity antibiotic analysis was performed, this information was also analyzed.

Methodological Quality

The two authors assigned the methodological quality of the included studies according to the Center for Evidence-Based Medicine [1].

RESULTS

Articles

After the removal of duplicate articles, our initial search yielded 227 articles from Medline, Embase and Google Scholar. After title and abstract evaluation, a list of 56 articles was created for full review. After full review, 35 studies were deemed suitable for further evaluation and data collection.

Five studies recorded different articles from an institutional database and a national arthroplasty registry, all being level IV evidence. There were no prospective case series or randomized, controlled trials. Two studies were disregarded as they offered duplicate information [2,3]. Data was extracted into a standard worksheet for further analysis.

Infection Rates and Pathogen Assessment

A total of 303 infections were recorded out of 6,681 patients, for a mean infection rate of 5.6%. Of these, 301 were considered by the authors to be a deep infection for an infection rate of 5.2%, with the other two corresponding to superficial infection.

A pathogen was identified in only five studies. It was not specified if the infection was mono- or polybacterial in all reported case

series. Large et al. reported four cases of deep infection. Two were positive for *Staphylococcus aureus*, one for *Staphylococcus epidermidis* (*S. epidermidis*) and one with no growing organism but a clinical diagnosis of infection [4]. Antuña et al. reported on the outcome of semiconstrained TEA after fracture of the distal humeral and observed 3 infections in 16 patients, 2 being positive for *S. epidermidis* and 1 having negative cultures [5].

Peden et al. reported on the outcome for TEA for an ankylosed or fused elbow, reporting 3 infections out of 13 cases. One occurred perioperatively and the other occurred at 2 and 15 years. Two cases were diagnosed with *Staphylococcus coagulase negative methicillin-resistant* and *S. aureus* [6]. Tachihara et al. reported on the outcome for TEA for rheumatoid arthritis and reported on three infections positive for *enterobacter*, *pseudomona* and *S. aureus*. In all of those cases, the infection was considered monobacterial [7].

Curiously, in a clinical series reporting on 20 elbows diagnosed with periprosthetic joint infection, Streubel et al. reported that 6 out of 21 infections were polymicrobial [8]. In that series, the most frequent pathogen was S. Coagulase-negative (13 patients) followed by *S. aureus* (9 patients) and *Corynebacterium* (3 patients). These patients were initially treated with vancomycin in 10 cases, cefazolin in 8, rifampin in 3 and ceftriaxone in 1 case [8]. This information is in accordance with other studies, although there is a risk of a partial duplicate patient population. In a group of 51 patients, Zarkadas et al. found 17 cases of *S. aureus*, 11 of *S. epidermidis*, 1 of *Serratia*, 1 of *Costiridium*, 1 of *Mycobacteria*, 1 of *C. acnes*, 10 multiorganism infections and 8 cases in which no bacteria was actually grown [9].

Although they are obviously universally used, only 4 of the 35 studies specified the use of prophylactic antibiotics. Of these, only 2 mentioned in their methods the type and dose of antibiotic (a first-generation and a second-generation cephalosporin prior to skin incision in both) [10,11]. Kodde et al. reported the use of 1 gm of intravenous cefazolin 30 minutes prior to skin incision and extended the use for 48 postoperative hour [10]. Lami et al. reported the use of systematic prophylactic antibiotic at induction using a second-generation cephalosporin with no further description. No other information regarding the duration of perioperative antibiotic therapy has been found.

Discussion

The available information is poor regarding infection as a complication after elbow replacement. Specific information on the pathogen, the type and dose of prophylactic antibiotic or the surgical prepping solutions used in cases complicated with an infection after elbow replacement are almost universally lacking in the analyzed studies. The reasons for this are unclear, but might be related to wording restrictions and focus on other aspects of research. Moreover, a definition of infection was not reported and different authors could have used different definitions.

Even though only four studies specified the use of prophylactic antibiotics, we assume these are universally used. Based on the scarce information found and our own clinical experience, first-generation cephalosporin seems to be the most widely used antibiotic. Other options could be used, based on allergies, intolerance or concomitant diseases. However, no sound conclusion can be extracted from literature on this regard.

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QUESTION 2: What is the evidence and recommendation for the use of antibiotic-laden bone cement (ALBC) in primary total elbow arthroplasty (TEA) or in revision TEA?

RECOMMENDATION: There is inadequate evidence to support the use of ALBC during primary or revision TEA.

LEVEL OF EVIDENCE: Consensus

DELEGATE VOTE: Agree: 96%, Disagree: 0%, Abstain: 4% (Unanimous, Strongest Consensus)

RATIONALE

The response to the question regarding the value of ALBC in a primary and revision setting of TEA requires an understanding of several issues:

1. The specific answer to these questions referable to the elbow cannot be directly answered from the available literature addressing the elbow. Very little information exists for the