ORTHOPAEDIC IMPLANT RELATED INFECTION

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Abstract

Implant is widely used to correct deformation, to stabilize fracture site, and promote bone healing in several orthopaedic surgeries. The use of implant is usually having a higher risk of developing infection. Although the use of antibiotic prophylaxis and antimicrobial impregnated biomaterial are used in cases of surgeries. But, the emerging superbugs which resistant to antibiotics, biofilms formation, and chronic immune suppressing diseases and lifestyles are challenging issues to make good osteosynthesis. Author use orthopaedic implant related infection to explain about the infection associated with the use of orthopaedic implants. This article attempts to discuss about infection associated with orthopaedic implant surgeries and treatment possible to treat the infection during implant placement.

Keywords : Implant, infection, biofilm.

INTRODUCTION

Infection has become a concerning issue for the past decades and have devastating consequences regarding a bone healing of trauma. The World Health Organization (WHO) reported that SSI was the most reported as the main cause of infection in mid and low income countries with reported cases 1.2 to 23.6 per 100 surgeries. [(1)] An incidence studies showed Orthopaedic procedures takes in second most frequent procedures (15.1%; 95% CI: 10.2–20.6) in which SSI occurs. [(2)] In a clinical research conducted by Putra YAK & Semita on 30 open fracture patients at Soebandi General Hospital in Jember-Indonesia had showed 30% samples developed surgical wound infection. [(3)]

The increasingly use of implant in Orthopaedic and Traumatology also increase the risk of infection even though preventive measure and broad use of antibiotic prophylaxis have been done. [(4)] The defence mechanisms of microorganism, such as colonization and resistances of antibiotics, surpassed the antibiotics development. Enhance by these, the ability of certain microorganism (including Staphylococcus) to “build” glycocalyx -biofilms to adhere to foreign materials such as biomaterial has worsen the situation. Thus result in delayed bone healing and permanent functional loss. [(5)] [(6)]

The orthopaedic implant related infection may also have major socially and economically burden for both the patient and the healthcare system. The studies showed the cost for treatment was escalating for past years represent growing national economic healthcare burden. [(6)] [(7)] Infected implants also rendered unusable and have to be remove and change for the new one. Thus increase in healing time and cost for treating the infection. [(5)] [(6)]

DEFINITION

Currently there is no consensus regarding the implant related infection definition. In fact, various authors did not mention the infection some explains the conditions by their own unique naming and definition. [4] [6]While in contrast, Periprosthetic Joint Infection (PJI) is defines as "the presence of acute inflammation as seen on histopathologic examination of periprosthetic tissue at the time of surgical debridement or prosthesis removal **(B-II)."** [8]Although there was a similar clinical properties and treatment algorithm among Implant Related Infection, the definition for PJI still fails to explain if the infection after the implant placement was occurs in contaminated-wound fracture.

RISK FACTORS

A. FRACTURE TYPES

Open type of fracture is more susceptible to be infected which risk increase depending on the severity of the fracture grades. [9] [10] [11]

B. INTERNAL FACTORS

Smoking, diabetes, a history of stroke, heart failure, elderly patients, intravenous drug addicts, and socially disadvantaged patients are at high risk of implant-related infection. HIV-infected patients are at increased risk for osteoporosis, and fractures of all types. [11] [12] [13]

CLASSIFICATION

Orthopaedic implant-related infection can be categorized based on pathogenesis, pathoanatomical, or time interval. Classification by pathogenesis can be categorized into perioperative, exogenous, and haematogenous infection. [14] ICS Classification (acronym from Infection, Callus, and Stability) manages the infection according to pathoanatomical type of osteosynthesis (table 1). [14] [15]

Type	Pathoanatomical finding
I	Stable osteosynthesis with callus formation
II	Stable osteosynthesis without/scarce callus formation
III	Unstable osteosysntesis with absent of callus formation

Table 1 ICS classification based on pathoanatomy when infection occurs. [15]

Willeneger and Roth classify the infection by time of onset into three groups, early onset (less than 2 weeks), delayed onset (2-10 weeks), and late onset (more than 10 weeks of infection). [6] [16] Although implant-related infection are depends on the bone stability and loosening of the implants, this classification helps physicians to empirically treat infections especially in early onset.

	Time of Onset	Possible Pathogens	Features
Early	Less than 2 weeks	Staphylococcus aureus	Classical sign of inflammation, systemic signs, haematomas, healing impairment. Immature biofilm formation.
Delayed	2 to 10 weeks	Staphyloccus epidermidis	Combination of early and late signs (Classical sign with possible pus formation). Mature biofilm formation.
Late	Indefinite (More than 10 weeks)	Staphyloccus epidermidis and others less virulent microorganism	Absent of classical sign of inflammation. Pus formation and/or fistulas. Mature biofilm formation.

Table 2 **Willeneger and Roth classification of infection**-this classification group infection by time of onset when occurs. [16]

PATHOMECHANISM

Bacteria involved in implant-related infection usually don"t correlate with the initial infection when trauma first occurs or the bacteria taken from swab of wound after revision surgery. Therefore three bone biopsies should be taken at the site of implant, necrotic tissues, and non-union in case of infection suspected. [6]

Pathogen	Rate of infection
Gram Positive	
Staphylococcus aureus	20-30%
Coagulase-Negative Staphylococci(CoNS)	20-40%
Streptococci	1-10%
Enterococci	1-10%
Gram Negative	
Pseudomonas aeruginosa	6-17%
Enterobacteriaceae	6-17%
Anaerobes	
Proponibacteria and Peptostreptococci	4-5% (except Shoulder procedure account for 38%)

Table 3 **Common pathogens associated with implant-related infection.** [9] [13] [17]

Bacteria are categorized by planktonic and biofilm form. In Planktonic form bacteria are free-floating, have active metabolism and replicate rapidly but susceptible to host immune response and antibiotics. When expose with adverse environmental factors, bacteria will undergo biological changes into multicellular, complex three-dimensional structure enclosed with exopolysaccharides, with less active metabolism but become more resillient againts harsh environment than planktonic form, which become biofilm form. Bacteria in biofilm form are stationary in metabolism but can withstand mechanical and majority antibiotics which making it difficult to treat. [18] [19] [20]

Bacteria in biofilm form are categorized by 5 stages of development. **Stage I** is reversible binding phase which likely initiated by environmental signal of the host.

Hydrophobic and coarse surface are much likely to develop biofilm due to reduction of shear force and increased surface area. **Stage II** is characterized by irreversible attachment of bacteria to the tissue or implant surface. During this stage, attached bacteria is emitting biological signal until certain threshold which produced exopolysaccharides entrapping floating bacteria and nutrients while replicating. **Stage III** is called maturation-1 in which biofilm thickness increased until 100mm which called **Stage IV** or maturation-2. Stage IV biofilm makes bacteria lies underneath isolated from outer layer. **At stage V** some bacteria become planktonic phase and spreading to other tissue surface thus the whole stages develops all over again. (21)

The microorganism may enter musculoskeletal tissue through various pathways:

1. By direct contact to the tissue. The microorganism may enter from the breakage of the skin tissue (as first barrier of the body) to the musculoskeletal tissues.
2. Spread from other contagious focal infection. An infection from adjacent organs may infect the bone.
3. Haematogenous infection via bloodstream. The respiratory, bowel, or urinary tract infection may spread from distant organ infection via bloodstream. (5)

Once in contact with host tissue, bacteria will trigger host immune responses which activate macrophage to phagocyte bacteria. The bacteria will then develop biofilm as the act of it defence mechanism which hinder the phagocytic process of macrophage and making extensive destruction to surrounding tissue. Incompatible biomaterial will also initiate host immune system as the response against foreign body. Lesser biocompatible material will trigger greater cytokine reaction. Macrophage who unable to engulf the material which larger in size than it will exhaust. Together with the infection, biomaterial immune reaction will impair the implanted device. (9) (22)

DIAGNOSIS

Clinical Sign and Symptoms

The clinical of infection following orthopaedic implants varies individually. Severity of infection, tissue damage, stability of fracture, and time of onset infection occurs involved in clinical manifestation. Other chronic illness such as chronic immune compromised also play major role not only for prolonged healing time of fracture but also treatment plans of infected osteosynthesis. (6) (9)Classical symptoms such as increasing local pain, purulent discharge, swelling, and erythema are featured in acute onset of infection. As for late onset which caused by less virulent pathogens, the severity of local symptoms is usually milder.

Imaging

Plain radiography usually fails to recognized changes in acute setting of infection. Therefore, serial x-ray is recommended for spotting changes. Computed Tomography (CT) may be useful to locate sequestrum, healing process of bone, and infection. CT with contrast is quite specific to determine border of abscess. Magnetic Resonance Imaging (MRI) is less

favourable because of metallic artefact but helpful to determine the sequestrum and infection to adjacent tissue. [6] [9]

TREATMENTS

Prosthetic Joint Infection (PJI) management is similar yet different from Fracture Related Infection (FRI). Implant placement in PJI require implant to be hold as long as possible while FRI implant device may be remove when fractured site is healed. Complete removal source of infection may not be first step of treatment. Two strategies of treatments should be considered. The first strategy consists of debridement, specific antimicrobial therapy, and retention of the implant. [23] While the second one, consist of debridement, specific antimicrobial therapy and removal or exchange of the implant. Debridement of pus collection, necrotic tissue, and wound dressing should be kept aggressively with adequate local tissue sparring. [24]In rare case when there is an extensive tissue necrosis and limb salvage procedure not possible, the limb amputation may be indicated.

Management in early onset of infection

The stability of fracture is the „key" for management consideration. If the stability of the fracture can be maintained and the total debridement can be performed the implant can be kept, otherwise implant exchange and debridement should be considered. [6] Erythema, discharge and breakdown of the skin should be suspect of early infection. Several tests should be performed to locate possible deeper tissue infection. Elevated white blood count, sonography and CT imaging can be useful to detect infection and sign of pus collection. Systemic antimicrobial therapy should be given for 2 weeks with possible implant retention. The collection of pus and sequestrum must be drain and excise properly. [24]

Management in delayed onset of infection

In 3 until 10 weeks of implant placement usually the union of fractured site was yet complete. Biofilm formation is at immature stage and can be debride properly. Intramedullary nails infection is relatively late to diagnose and hard to accessed surgically despite high retention success rate. [24]The management of delayed onset of infection are similar in management in early onset.

Management in late onset of infection

After 10 weeks of implant placement treatment are shifted whether bone union are achieved. In complete bone union, debridement and removal of the implant are performed. While in non-union, multiple factors should be considered. Delay in diagnosis, extensive tissue necrosis, implant failure, sequestrum and mature biofilm formation are common cause of non-union healing. The necrotic tissue should be debride properly improving tissue growth. The loose implant should be exchange to maintain good bone stabilization and sequestrum should be excise properly. [24]

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