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A Conspectus on the Diagnosis and Treatment of Periprosthetic Joint Infection

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Abstract

Periprosthetic joint infection (PJI) holds a desolating complication sub-sequential to arthroplasty and is affiliated with consequential patient morbidity. It is roughly classified as early post-operative acute hematogenous and late chronic infection. There is an increase in the number of PJIs in males in comparison to females and in smokers compared to non-smokers. The organisms such *Staphylococcus* spp., *Mycobacterium* spp., *Candida* spp. and β-hemolytic *Streptococci* spp. were found to be associated with PJI. According to some studies, *S. aureus* was noted to be the most common bacterium responsible for PJIs. The accurate preoperative, postoperative and intraoperative infection diagnosis is extremely important. For the diagnosis of deep implant infection, usually, integration of patient's physical examination, history, laboratory examination and joint aspiration are enough. According to many studies for diagnosing the infection of knee and hip arthroplasty, C-reactive protein level and erythrocyte sedimentation rate are ad hoc (precise) and responsive. To treat PJI's, there are many possible treatment methods, but the protocols are not meticulously followed. For early PJI, the universal treatments of choice are debridement, antibiotics, irrigation and retention of the prosthesis. There are various definitions and classifications given for ruling out PJI's. In many studies, the diversity of treatment and diagnosis is a restriction; hence PJI's outstanding treatment endures ambiguous. Further, the antibiotic-resistant *Mycobacterium* also makes it more challenging for the surgeons. This review describes the summary of diagnostic tools and treatments of PJI in use.

Introduction

Periprosthetic joint infection (PJI) holds a desolating complication sub-sequential to arthroplasty and is affiliated with consequential patient morbidity. Higher than 25% of revision surgeries are associated with these infections and are likely to increase [1]. The incidence of PJI interpreted about 1% to 2% postliminary to total hip arthroplasty (THA) and 1% to 4% postliminary to total knee arthroplasty (TKA) [2]. Bygone the previous decade, the treatments of affected patients are encountered with more morbidities than in the past. The susceptive organisms for PJI are progressing to convert much harder to treat [3]. For the favorable outcome of treatment of PJI, a precise and mercurial diagnosis is necessary [4]. The new definition of PJI was proposed by workgroup congregated by the Musculoskeletal Infection Society (MSIS) through analyzing the available evidence [5]. In the USA, PJI's are diagnosed to be an indication of revision THA at the third most common place [6], and it is also associated with several risk factors which can be modified [7]. The risk factors which can be modified according to some studies are obesity, malnutrition, alcoholism, extensive anticoagulant treatment, allogeneic blood transfusion [7]. Because of deep PJI, there is a drastic socioeconomic and medical implication as it is the most common reason for revision surgery and implant failure following total joint arthroplasty. PJIs continue to occur most commonly even after implementing the systematic approach like preoperative antibiotics administrations, operating room with clean air and exhaust that decreased the complications but it is not completely eliminated [8, 9].

Classification of PJI of the Hip and the Knee

It is roughly classified as early post-operative acute hematogenous and late chronic Infections [10]. The classification for PJI of the hip include four types: Type 1, for patients sustaining revision surgery because of non-infectious etiology, includes positive intraoperative cultures; type 2, early infection that is developed within the period of one month postoperatively; type 3, late infection developing within the period of more than one month and type 4, the infections which are acute hematogenous in nature and are responsible for bacteremia [11]. The classification of PJIs of the knee include: Type1, an intraoperative culture which is positively collected during revision surgery because of a reason which is not infection; type 2, these are the infections which occur within four weeks of surgery and are subdivided to type 2A which are superficial and type 2B which are deep; type 3, after the time period of more than four weeks postoperatively, the acute hematogenous deep infection which occurs are classified into this type and type 4, the deep infections which are developed after four weeks from the time of start of procedure [12].

Risk factors related to PJI

There is an increase in the number of PJIs in males in comparison to females and in smokers when compared to non-smokers when sociodemographic aspects were evaluated [13, 14]. Comparability between underweight to normal and overweight was evaluated in one study, for category BMI, noted that the risk was higher for that in the underweight group [15]. In patients having diabetes mellitus, there is an increased risk of occurrence of infections such as non-surgical site and surgical site post total hip replacement [16]. A lot of the discussed risk factors related to PJIs following total joint arthroplasty stayed disputable [17]. After the total joint arthroplasty, the contemporary smokers were at the increased risk of infectious complications [18]. The younger patients were found to be at higher risk, usually less than fifty years of age for revision surgery post-TKA [19]. The association between fistulas and recurrent infections was found, according to a study [20]. There was also an increased rate of risk with reconstructions allografts [21]. According to a report, there were several risk factors such as osteoarthritis, BMI>30kg/m^2, rheumatoid arthritis, male gender, hypertension, steroid therapy and diabetes which was associated with deep infection [22]. Many nosocomial and surgical related risk

factors were found to be associated with PJI in addition to patient-related risk factors [23].

Organisms in association with PJI

The organisms such *Staphylococcus* spp., *Mycobacterium* spp., *Candida* spp. and β-hemolytic *Streptococci* spp. were found to be associated with PJI [24, 25]. According to Bejon et al. [26], the organism which was isolated most commonly in their study was coagulase-negative *Staphylococci*. The uncommon pathogens found to be in association with PJI were *fungi* or *Mycobacterium* [27]. In a few patients with obvious prosthetic infections, the *Mycobacterial* cultures, *fungal* cultures or both should be taken into account if the results of bacterial cultures are negative [25]. Studies also surveyed the data for using the dental procedures and prophylaxis because they found the connection between dental procedures and anaerobic PJI [28]. For proper treatment and establishment of antimicrobial prophylaxis in replacement, it is cardinal to recognize the range of PJIs *Mycobacterium* aetiology [29]. According to some studies, the aetiology was 84% mono-microbial and 16% poly-microbial [30]. The therapeutic failure was found to be in association with microorganisms which form biofilm [31]. Some of the rare accumulation of virus and fungi causes infectious arthritis [32]. Another rare cause of PJI is rapidly growing *Mycobacteria;* hence with negative results of bacterial cultures, the patients must be suspected [33].

Diagnosis and definition of PJI

According to the criteria proposed, the existence of PJI is when: (1) Presence of sinus tract corresponding with prosthesis; (2) the isolation of the pathogen is done by taking two different fluid and tissue samples from culture of involved prosthetic joint and (3) If presence of four criteria out of the six criteria as follows [5]:

(a) Exalted count of the synovial leukocytes.
(b) If observation of histologically evaluated periprosthetic joint tissue by ×400 magnification shows higher than 5 neutrophils per high-power field in 5 high-power fields.
(c) The concentration of serum C-reactive protein (CRP) and erythrocyte sedimentation rate is exalted.
(d) *Mycobacterium* segregation of periprosthetic fluid and tissue in single cultures.
(e) Prudence existence in involved joint.
(f) Exalted synovial neutrophil percentage.

The accurate preoperative, postoperative and intraoperative infection diagnoses are extremely important [34]. For the diagnosis of deep implant infection, usually, integration of patient's physical examination, history, laboratory examination and joint aspiration are enough [34]. According to many studies for diagnosing the infection of knee and hip arthroplasty, C-reactive protein level, and erythrocyte sedimentation rate is ad hoc (precise) and responsive [35]. Another report said that rectification of synovial fluid white blood cell count (WBC) preoperatively is a voracious test [36]. The important preoperative testing indications were the white blood cells count of more than 3000 per ml in the synovial fluid cell count, according to a few studies [37]. An extremely accurate marker like procalcitonin may be utilized for the identification of the patients with actual positive interleukin-6 and C-reactive protein levels [38]. The intraoperative frozen section is often a final resource for the surgeons to obviate the infection at the instance of surgery as it is generally available [39]. The auxiliary examination to differentiate between septic and aseptic laxation are the intraoperative frozen section [40]. Utilizing sonication for the diagnosis of PJI has been proved promising for the detection of the pathogen; it is more accurate than the conventional tissue culture as it has lesser specificity, favorable for the patients who had the history of taking antibiotics [41]. Few studies concluded that the use of VAT MRI is advantageous for detecting PJI because it showed increased levels of accuracy, sensitivity, and conformity for soft tissue edema, bone destruction, periprosthetic irregular soft tissue mass and fistula formation in patients with hip replacements [42]. For diagnosing the infection, Bandits cut off is supposed to be the most authentic intraoperative histological criteria [43].

Various treatment methods of PJI

To treat PJI, there are many possible treatment methods, but the protocols are not meticulously followed. For early PJI, the universal treatment of choice is debridement, antibiotics, irrigation and retention of the prosthesis (DAIR) [44]. To prevent the hematogenous infection following arthroplasty, proper oral hygiene should be maintained and to treat periodontitis before arthroplasty. The prime focal point of the hematogenous infected prosthesis of the hip is periapical dental abscess [45]. According to a study, in early postoperative infection cases, there was a higher rate of success in retaining the implant, if the treatment for all patients is carried out within two days of onset of first symptoms by open surgical debridement, and revision for every removable component and irrigated using octenidine (antiseptic solution) [46]. If the implant is stable by retaining the prosthesis the treatment of TKR and THR can be carried out and by utilizing the local antibiotics such as gentamicin-PMMA beads or gentamicin-collagen fleeces are helpful [47]. Few studies showed that in preferred situations, irrigation, debridement, and retention of the component of prosthesis outcomes in relatively lesser morbidity and higher progression [48]. But according to different studies, the compatibility of irrigation and debridement to restrict the infection even if in early postoperative period is constrained [49]. For bone and soft tissue infections, the local application of gentamicin-containing collagen sponge is newly introduced, but there was more release of gentamicin from the sponge when compared to polymethyl-methacrylate (PMMA) beads *in vitro* [50]. To prevent and reduce the infection rates following joint arthroplasty, prophylactic antimicrobial administration delivering enough drug level at the time of surgery and from 24 hours to 14 days are proven to be effective. Maintaining the asepsis operating room and patient preparation prior to surgeries is important [51]. Antibiotic prophylaxis prior to the surgery of orthopedic implant is found to be effective for protecting the implant against bacterial colonization. So, selection and administration of the antibiotics should be done carefully [52]. For deep gram-negative skeletal and muscle infections, temporary treatment with local gentamicin beads should be used rather administering tonic antibiotics [53].

Antibiotic resistance in PJI's

Post-surgical PJIs of knee and hip surgeries are noticeably reduced with antibiotic prophylaxis. But there is increasing resistance to antibiotics, which has upraised the focus on adequateness of antibiotic prophylaxis [54]. The process which is the reason for an unsatisfactory outcome after irrigation and debridement in relation to acute total knee arthroplasty PJI is antibiotic resistance biofilm [55]. PJI's treatment remains questionable with antibiotic administration like *Staphylococcus* was found methicillin resistance. In cases like 2-stage arthroplasty, where vancomycin is utilized, there were reports of increased failure. Hence, according to a few studies, the methicillin-resistant *Staphylococcus* PJI's can be safely treated with the use of systemic daptomycin in combination with daptomycin-impregnated cement [56]. The preoperative antibiotic with vancomycin in relation to primary joint arthroplasty showed decreased rate of methicillin-resistant *Staphylococcus aureus* (MRSA) and PJI's [57]. According to a few studies ^{14}C-labeled daptomycin administration was found to be effective against methicillin-resistant *Staphylococcus* in divided doses such as 4 to 6 mg/kg/day [58].

Future recommendations

In consequence, we observed a vast difference among the present diagnostic criteria of periprosthetic joint infections. For the convinced patient's diagnosis suffering from defeated joint arthroplasties, there is an intense requirement of PJI's common diagnostic criteria which will also enhance the PJI research. We consider that PJI will abide a great challenge for the medical professionals in future. In order to reduce the frequency of complications due to this infection, the implementation of past studies should be done and risk factors should be minimized with a productive approach.

Conclusions

In patients with past PJI inclines to consecutive PJI in primary TKA or THA. If PJI is evolved in one joint, the other joint is also at a greater risk for the same patient. There are various definitions and classifications given for ruling out PJI's. In many studies, the diversity in treatment and diagnosis is a restriction, hence PJI's outstanding treatment endures ambiguously. There is also a contribution of various risk factors such as age, sex, socio-demographic aspects increasing the difficulty in treating PJI's. A wide variety of microbes are involved in causing this infection, which includes aerobic and anaerobic *Mycobacterium* and fungi. There are reports of many treatment methods for PJI's such as DAIR, irrigation and debridement, etc. But antibiotic-resistant *Mycobacterium* makes it more challenging for surgeons to succeed in the treatment plan. Therefore, the counseling of the caregivers and the patients should be done in such a way that they should understand that even if there was enough treatment for PJI previously, patients are at higher risk of developing PJI's in future.

Conflicts of interest

The authors declare that they have no conflict of interest.

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