Analysis on Prevention and Treatment of Infection After Replacement Operation on Hip and Knee Prosthesis

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Abstract: Artificial replacement operation on hip and knee prosthesis can result in many postoperative complications, among which postoperative infection is the most harmful and the most common. In this paper, the methods on prevention and treatment of infection in hip and knee after replacement operation and clinical experience were summarized and discussed to provide theoretical basis and empirical support for clinical practice. The analysis results will be conducive to control and cure postoperative infection symptoms, thus the quality of life of patients and their families will be correspondingly improved.

Knee joint and hip joint are important weight-bearing joints of lower limbs with complex and important structures and functions. In the current operation of orthopedic clinic, hip and knee replacement operation, a conventional surgery, is one of the most successful surgical operations since the 20th century, but often with postoperative complications. Common complications include infection, venous thromboembolism, secondary ischemia of recessive blood loss, etc. [1, 2], and loosening joint prosthesis, postoperative pains, and functional loss of hip and knee joints. Due to the high disability rate and high cost of treatment, hip and knee replacement operation has attracted more and more attention in clinical practice in recent years.

The most common seen complication after operation on hip and knee joint is postoperative infection. Once infection occurs, the success rate and postoperative recovery in each stage of surgery will be greatly influenced [3] leading great burden on the life and economy of patients. Retrospective analysis showed that patients with replacement surgery on hip and knee prosthesis will be confronted with the possibility of high infection, and infection rate of the surgical site accounted for more than 6% of all cases[4].Preoperative patients with other chronic infections, rheumatoid arthritis, diabetes mellitus, tumor and other basic diseases are more likely to have postoperative infections [5] [6].Studies have also shown that the risk of infection during the second operation is higher than that during the first operation [7].

This review summarizes the methods of avoiding, treating and intervening infection after the replacement operation on hip and knee prosthesis.

1 Risk Factors of Surgical Infection and Methods for Circumvention

1.1 Septic arthritis

Joint tuberculosis and other infectious joint diseases are absolute contraindications. Postoperative infection after hip and knee surgery can be divided into early infection (within 3 months after surgery), delayed infection (3-24 months after surgery) and infection in end period (metastatic disease 24 months after surgery). The causes of infection also include host related factors and iatrogenic factors. Prevention of infection begins before surgery.

1.2 Preoperative Evaluation

Not all patients with hip and knee disorders are suitable for joint replacement surgery, especially those who are prone to infection. First of all, for patients with low immunity, it is easy to cause infection if the operation is performed. In this case, the surgeon's limited ability to intervene with

the host can lead to a gradual exacerbation of the infection, so surgery should be avoided when the patient's immune system is weak or impaired. Second, patients are at a high risk of postoperative infection when they have infections and inflammation (such as ulcers) in other parts of the body before surgery. Therefore, the pathogenic bacteria should be thoroughly eliminated before operation to prevent translocation infection. Moreover, for diabetic patients, high blood glucose concentration in the body is conducive to bacterial reproduction and development, so the blood glucose level of diabetic patients should be strictly controlled. The synovial membrane of patients with rheumatoid arthritis has relatively serious lesions, and there is still a residual pathological basis after surgery. Increased exudation will increase the chance of infection [8].Anticoagulants, such as heparin, are also a risky factor for postoperative infection in patients with heart disease.

In addition, other complications and infections, the preoperative factors such as patients' age, gender, nutrition, obesity, smoking and drinking habits, the use of prophylactic antibiotics and others can all exert effect on the occurrence of infection, and the infection rate increases with the extension of the hospital stay before the operation.

1.3Intraoperative Control

The pathogenic bacteria of infected incision mainly come from hospital environment, medical staff and patients themselves. The pathogenic bacteria include Staphylococcus aureus, staphylococcus epidermis, Escherichia coli and streptococcus hemolyticus. Once entering into the body, it is easy for these bacteria to cause infection (among which staphylococcus epidermidis infection accounts for 40.0% in the infection around hip prosthesis, and staphylococcus aureus infection accounts for 54.5% in the infection of knee prosthesis) [8].In order to avoid intraoperative wound infection to the maximum extent, the operation should be completed in operation rooms at level of 100, and studies have proved that the use of laminar flow operating room can effectively reduce the incidence of postoperative infection. During the operation, personnel movement between operations should be strictly controlled and sterile management during the operation should be strengthened, and prophylactic antibiotics should be added as in favorable conditions [6].

The operation with duration of three hours or more is directly related to postoperative infection [9].The main reasons lie in the facts that the number of bacteria increases with the exposure time of the wound and the decreased immunity of the organism due to bleeding and prolonged anesthesia. The chances of infection are increased by the lack of aseptic operation due to fatigue and the inability to carefully handle soft tissue, resulting in body residues, etc. Therefore, it is necessary to strictly control the operation time, and the technical proficiency of doctors should be improved so as to completely remove necrotic tissues and residues. The time for skin preparation (the infection risk of preserving skin during the day for operation can be decreased compared with that before operation) and allogeneic blood transfusion (autologous blood transfusion is effective in reducing the infection rate compared with allogeneic blood transfusion, because allogeneic blood will reduce the immune response of the body) also have a significant influence on the incidence of postoperative infection.

1.4 Postoperative Protection

After replacement operation on hip and knee prosthesis, the wound surface must be kept clean to avoid inflammation, swelling and other reactions. To actively deal with the factors that may cause postoperative infection, such as persistent purulent effusion, delayed wound healing, hematoma, etc. The presence of exudate can be regarded as a risk signal of infection, and the use of drainage tube can effectively reduce the formation of hematoma[3], thus reducing the risk of postoperative infection. The higher the postoperative drainage volume, the higher the risk of joint prosthesis infection [8].Patients with urinary tract infections after surgery also had a higher risk in the operation site. Patients can also take anti-inflammatory drugs to prevent infection, such as metronidazole, cephalosporin, penicillin capsules or erythromycin, etc., and the drugs should be opted according to the specific condition of patients to avoid allergic reactions.

Patients should also try to keep a good diet and actively carry out rehabilitation training after replacement operation on hip and knee prosthesis, which is beneficial to improve body immunity

and reduce the risk of infection.

2 Treatment and intervention after infection

The main cause of early infection lies in poor wound healing. When fat liquefaction occurs, the hematoma after liquefaction should be cleared and the wound should be re-sutured and the dressing should be changed. To reduce the risk of infection of delayed artificial joint, it is necessary to improve the patient's overall immunity. When chronic infections occur around the prosthesis, the prosthesis needs to be removed and the new joint can be implanted after the infection is completely resolved.

1.3 2.1 Medication Treatment

As the joint is complicated with infection after operation, pathogenic bacteria (drainage fluid, joint puncture fluid or local secretions from infected wounds) should be isolated and cultured first for drug sensitivity test and drugs with low drug resistance rate should be selected for timely and effective treatment. Drug selection should be based on monitoring results in drug resistance, and the actual situation of the hospitals should also be taken into consideration (a variety of common pathogens and possible pathogens can be seen in postoperative infection) for targeted selection of drugs. In general, antibiotic therapy is usually conducted with surgery, and the pure application of drug is only suitable for long-term antimicrobial therapy [10].Systemic antibiotics are administered after infection is confirmed.

Rifampicin, as an ideal fungicide, has a remarkable effect on all kinds of microorganisms. The integrated use of quinolones can make up for the defect that staphylococcus is prone to develop drug resistance. The effects of ciprofloxacin and of lexicon have been widely verified.

There are also clinical data showing that in the early stage of joint replacement, after the thorough debridation of the surgical lesion and the retention of the joint prosthesis, the absorbable drug-loaded calcium sulfate particles placed in the joint cavity can effectively treat the prosthesis associated infection.

2.2 Surgical Treatment

Surgical treatment is frequently seen in local debridement, secondary revision, primary revision and prosthetic debridement. Arthroplasty is also performed to restore the painless movement of the joint and to allow the relevant muscles, ligaments, and other soft tissues to control the movement of the joint normally. In pessimistic state of the patients (such as the patient fails to have the ability for exercise, poor bone mass and soft tissue coverage as well as high risk for revision, pathogens with drug resistance fail to be treated with drugs),the permanent joint prosthesis will be removed. Even in more serious cases, amputation will be the last option [11].

The analysis on the mostly commonly cases are demonstrated as follows:

2.2.1 The Second Stage of Revision

The joint with lesion is exposed from the original incision, the prosthesis is removed or retained after complete debridement, or a placeholder is implanted (usually antibiotics with mixed concentration of 15% in bone cement).Antibiotics were applied among the interval of the two revision periods (2.5 to 8 months).Secondary debridement is required in case of occurrence of infection. If the infection is controlled or no infection is found, the prosthesis can be re-implanted, and postoperative routine antimicrobial therapy can be performed. Although the revision at the second-stage has a very high cure rate for infection and is usually most commonly used in clinical practice, there are problems such as long treatment cycle, high cost and poor recovery for joint function after operation [12].

2.2.2 The First Stage of Revision

Complete debridement of sinus tract, scar, hyperplastic synovial tissue, infected tissue, and bone was performed. As the prosthesis was removed, the new prosthesis was implanted[11].The cost of

this operation is low, and function training of for joints of patients can be immediately performed after the operation, but the effect on controlling infection is not ideal. The operation is suitable for patients with light infection and those applied with sensitive antibiotic therapy. In a study, 126 patients received one-stage treatment for non-bone cement prosthesis; vancomycin or imipenem powder was put into the medullary cavity. The results showed that the cure rate of non-bone cement prosthesis of revision in one stage for treatment of infection around chronic hip prosthesis was as high as 89.2%.This method may become a new way for the treatment of postoperative infection after one-stage revision surgery [12].

2.2.3 Debridement for Residual Prosthesis

Under the condition that the pathogenic bacteria were identified, debridement with prosthetic retention can be performed to maintain intraoperative bone mass and reduce the risk of fractures around the prosthesis, which can effectively control infection. This operation was characterized with the advantages of low cost and moderate trauma, and is thus suitable for patients with acute infection (infection occurred within three weeks) but is subject to the condition of patient's soft tissue [11][13].

2.3 Biological Treatment

With the rapid development of biological science and technology, biological therapy for postoperative infection has gradually become a new method, but the current technology and application methods are required for further improvement. The two articles published in 2019 by Li Shuo and Xu Yihong made a comprehensive analysis on biotherapy for per prosthetic infection against the current background[14].At present, biofilm dispersants (lysis agents), targeted therapy, passive immunity and novel drug sustained-release systems were adopted as the biological means for treatment of infections after operation. Hydrogels were endowed with the function to reduce the adhesion of bacteria on their own. As the hydrogel drug delivery system was formed, the drug can be released for up to 96 hours. On the other hand, phage can effectively shorten the treatment period of infection of surrounding prosthesis and was applied in practice after experimental verification at Ⅰclinical period. However, biological targeted therapy for infection was mainly achieved by drug delivery of nanomaterials to achieve slow and controlled release to reduce sudden release of antibiotics and label the characteristics of antibodies in recognizing specific pathogens to achieve targeted therapy for infected lesions. The efficacy of this therapy has been verified in mouse experiments, but its broad spectrum needs to be improved. At present, the biotherapy is given more priority on biofilm dispersants (such as dispersant B), targeted therapy with antibacterial agents, improvement of passive immunity and antibacterial coating of prosthesis through monoclonal antibodies and polyclonal antibodies[14].Antimicrobial coating on the surface of implants was conducted to effectively prevent implant-related infections, which gained popularity in clinical application.

Biotherapy, characterized by safety and efficacy and high level of acceptance by patient, is gradually transforming from basic experimental stage to clinical application, and will become an important method for treatment for postoperative infection after replacement operation on hip and knee .Studies have confirmed that 3D printed porous titanium rods with hydrogel vancomycin and polycaprolactone (PCL) film is endowed with the advantages in fighting against bacteria in an intelligent manner. In addition, the thermo-sensitive peg-B-polycaprolactone (PEG-B-PCL) gel can be used as a drug carrier to alleviate sudden drug release without damaging the antibacterial effect of vancomycin. The application of PCL in the intelligent antibacterial coating of implants has, to a certain extent, promoted the development of the treatment of postoperative infection.

2.4 Physical Treatment

Studies have shown that high-energy X-ray with higher radiation will exert stronger inhibition impact on fighting against staphylococcus aureus, Escherichia coli and Enterococcus facials. And the variation of bacteria at the radiation of 40Gy fails to be generated. Therefore, the appropriate amount of high-energy X-ray has a certain effect on the elimination of infectious pathogens.

However, due to the excessive amount of radiation in in habiting bacteria, the radiation rays cannot be used to control infection in clinical practice [15],which, however, offers a new way of thinking that, if harmless and bacteriostatic rays are found, all postoperative infections, including hip and knee replacements, may be completely resolved.

Conclusion

Failure of hip and knee surgery is usually manifested for several factors as the reoperation due to infection, prolonged sinus tract, continuous exudation, severe pain of affected joints and death caused by infection or continuous use of antibiotics after surgery. Infection accounted for 53% of the causes of hip and knee surgery failures (65% of early failures, 28% of mid-term failure, and 38% of late failures), and even 78% of revision surgery failures. Therefore, it is significant to be familiar with the risk factors, treatment and intervention methods of postoperative infection after replacement operation on hip and knee in clinical practice.

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