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## **Prevention of Periprosthetic Joint Infection**

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Additional information is available at the end of the chapter

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### **Abstract**

Prosthetic joint infection (PJI) is a serious complication with high morbidity, mortality, and substantial cost. The reported incidence is probably underestimated due to the problems of proper diagnosis. PJI has haunted the orthopedic community for several years and despite all the advances in this field, it is still a demanding issue with a huge impact on patients, surgeons, and healthcare. Numerous elements can predispose patients to PJI. In this chapter, we tried to summarize the effective prevention strategies along with the recommendations of a recent International Consensus Meeting on Surgical Site and Periprosthetic Joint Infection.

**Keywords:** Prevention, infection, total hip replacement, total knee replacement, total joint arthroplasty, periprosthetic joint infection

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### **1. Introduction**

Total joint arthroplasty (TJA) is one of the most effective surgeries in medicine and improves the quality of life and function level in most of the patients suffering from degenerative joint disease. Periprosthetic joint infection (PJI) is still a great challenge to the orthopedic community.

Since there is an escalating increase in the number of total hip and knee arthroplasties all around the world each year, the number of revision knee and hip procedures will also increase correspondingly.

The average incidence of periprosthetic joint infection (PJI) is between 0.25% and 2.0% within two years after primary total hip arthroplasty (THA) or total knee arthroplasty (TKA).[2-4] PJI is a serious complication of TJA; it is the primary indication for revision TKA and the third indication for revision THA.[5-7]

Not only is the diagnosis of PJI very challenging, its management is also very difficult. It requires multiple procedures, antibiotic therapy, and prolonged rehabilitation.[10] Its impact on the medical health system is probably greater than many other diseases.

Therefore, strong efforts to effectively treat PJI are mandatory. Treatment of the infection requires appropriate evaluation of the causing germ, the wound status, and the overall condition of the patient.

In this chapter, we will review PJI, its associated risk factors, and the current evidence available for the prevention of PJI.

## 2. Definition of PJI

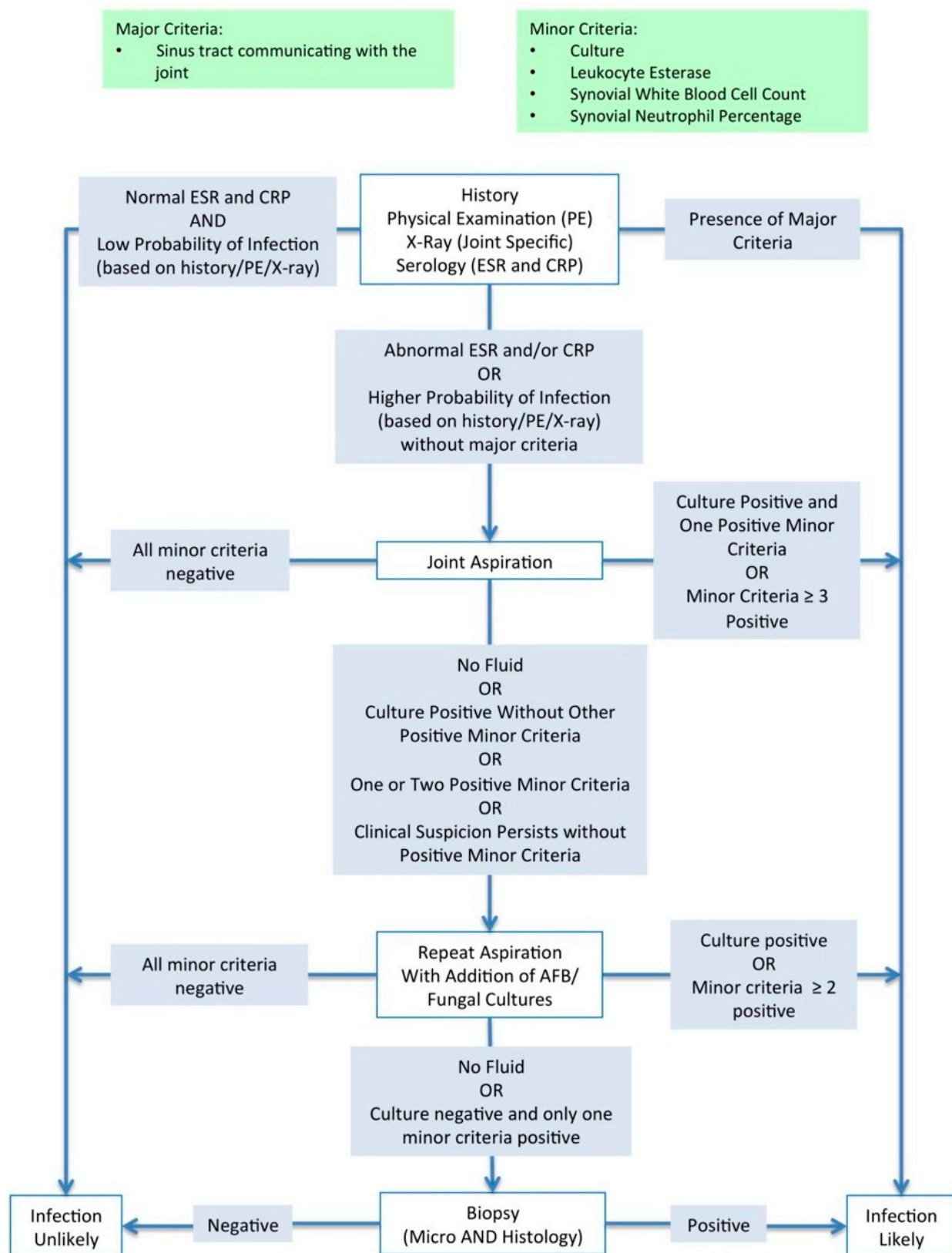
The first Consensus on Periprosthetic Joint Infection (2013) defined PJI as (Figure 1):

- Two positive periprosthetic cultures with phenotypically identical organisms; or
- A sinus tract communicating with the joint; or
- Having three of the following minor criteria:
  - Elevated serum C-reactive protein (CRP) AND erythrocyte sedimentation rate (ESR)
  - Elevated synovial fluid white blood cell (WBC) count OR ++change on leukocyte esterase test strip
  - Elevated synovial fluid polymorphonuclear neutrophil percentage (PMN%)
  - Positive histological analysis of periprosthetic tissue
  - A single positive culture

When upon histological analysis of periprosthetic tissue, greater than 5 neutrophils per high-power field in 5 high-power fields at  $\times 400$  magnification is observed, it is considered positive.

PJI may still be present if fewer than four of these criteria are met. Clinically, PJI may be present without meeting these criteria, in the case of less virulent organisms (e.g., *P. acnes*). Synovial leukocyte esterase can be performed as a rapid office or intraoperative point of care test using urinalysis strips.

AAOS has provided an algorithmic approach to the diagnosis of PJI. Clinical judgment should not be replaced by diagnostic algorithm or any one individual diagnostic laboratory test. By using this algorithm, preoperative evaluation leading to an aseptic diagnosis should not eliminate suspicion for PJI. If a patient has a history of persistent pain or stiffness in the



**Figure 1.** Diagnosis algorithm of periprosthetic joint infection.

prosthetic joint plus any of the following findings, he/she should be considered to have a higher probability of infection:

- Recent bacteremia;
- Multiple surgeries on the same joint;
- History of periprosthetic joint infection;
- Having an immunocompromised state, e.g., diabetes mellitus, inflammatory arthropathy, or malnourishment;
- Factors that increase risk of bacteremia, e.g., intravenous drug use, poor wound conditions, psoriasis, chronic venous stasis, or skin ulceration;
- Superficial surgical site infection in the prosthetic joint.

The following local findings are suggestive of PJI:

- Wound dehiscence
- Joint swelling, warmth, or redness

The following radiographic findings are suggestive of PJI:

- Radiographic findings showing loosening of a previously well-fixed component (especially the loosening seen within the first 5 postoperative years)
- Osteolysis or bone resorption around a component which should not be considered to be the result of wear, particularly if seen within 5 years postoperatively
- Subperiosteal elevation
- Transcortical sinus tracts

It is worth noting that plain radiographs are generally normal in the majority of PJIs.

The following approximate thresholds for the laboratory tests apply to those obtained fewer than 6 weeks from the most recent surgery:

- No threshold for ESR could be determined because this test is not useful in the diagnosis of acute PJI
- CRP > 100 mg/L (knee and hip)
- Synovial WBC count > 10,000 cells/ $\mu$ L
- Synovial PMN% > 90%

But if the tests are obtained more than 6 weeks from the most recent surgery, the following cutoffs apply:

- ESR > 30 mm/hr
- CRP > 10 mg/L

- Synovial WBC count > 3,000 cells per  $\mu\text{L}$
- Synovial PMN% > 80%

There is very limited evidence for the changes of inflammatory markers in patients with an underlying inflammatory arthritis and PJI. But there seems to be no change from the above thresholds for ESR, serum CRP, PMN%, and WBC count for PJI diagnosis in these patients.

In order to accurately analyze synovial fluid cell count, it is recommended that (1) synovial fluid WBC count results be analyzed with respect to the synovial red blood cell (RBC), serum RBC, and serum WBC concentrations to adjust for traumatic aspirations and (2) in joints with metal-on-metal bearing surfaces, a manual WBC analysis be performed.

Routine synovial fluid cultures should be maintained for 5–14 days. In cases of suspension to low virulence organisms or if in spite of high clinical suspicion to PJI, the routine preoperative cultures have failed to show bacterial growth (suspected culture-negative PJI) the cultures should be maintained for more than 14 days.

In proven or suspected PJI, AFB and fungal cultures should be limited to those patients at risk for such infections or when other traditional pathogens have not been identified and clinical suspicion persists.

It is recommended that at least three but not more than six distinct intraoperative tissue samples be sent for aerobic and anaerobic culture.

Before obtaining the culture samples, it is not necessary to withhold perioperative prophylactic antibiotics, except only in cases with a high suspicion for PJI in which an infecting organism has not been isolated.

The literature recommends that sonication of explants should be limited to cases of suspected or proven PJI (according to the clinical presentation or laboratory testing) in which preoperative joint aspiration result is not positive or the patient has received within the previous two weeks.

Laboratory tests based on detecting nucleic acids are not currently recommended as a routine diagnostic test for PJI. In patients with high clinical suspicion of PJI but negative cultures or other laboratory tests, molecular techniques may be helpful to identify the unknown pathogens or antibiotic sensitivity.

Although the plain radiographs may be negative, in all cases of suspected PJI, plain radiograph should be performed. But, magnetic resonance imaging (MRI), computed tomography (CT), and nuclear imaging currently do not play a significant role in the diagnosis of PJI but may be helpful in ruling out the other causes of joint pain/failure.

### 3. Prevention of PJI

Development of PJI depends on both host and environmental factors, and the best way to prevent it is to improve these two factors during the pre-, intra-, and postoperative phases.



Host factors:

Preoperative factors: These factors include, but are not limited to, history of previous surgery, male gender, poorly controlled diabetes mellitus (glucose > 200 mg/L or HbA1C > 7%), diagnosis of posttraumatic arthritis, malnutrition, prior surgical procedure in the affected joint, morbid obesity (BMI > 40 Kg/m<sup>2</sup>), recent hospitalization, severe immunodeficiency, active liver disease, chronic renal disease, inflammatory arthropathy, excessive smoking (>one pack per day), excessive alcohol consumption (>40 units per week), intravenous drug abuse, and extended stay in a rehabilitation facility.[4, 22, 23]

The impact of various risk factors appears to be accumulative.[24, 25] Lei et al. and Malinzak et al. have shown that any other medical comorbidity accompanied by diabetes leads to a higher risk of infection.[24, 29]

Thus, identifying risk factors and addressing them in the preoperative setting is critical to reduce PJI and other postoperative complications.

#### 4. Preoperative optimization of general health

Reports have shown that the general condition of the patient's health has a direct link with the rate of postoperative complications; and conditions such as ASA > 2, uncontrolled diabetes, and rheumatoid arthritis can significantly increase the risk of PJI. [4, 22, 26-28]

Therefore, it is mandatory to assess all patients in a multidisciplinary approach prior to TJA and to manage comorbidities if required. These assessments have shown to reduce the postoperative mortality rate and per-admission costs significantly in complex orthopaedic surgeries, including TJA.[30]

Marchant et al. found that patients with a higher level of hemoglobin A1c had significantly higher incidence of PJI, at an odds ratio of 2.31.[31]

Furthermore, Mraovic et al.[32] showed that patients with sugar levels of greater than 200 mg/dl on postoperative day one are at a higher risk of developing PJI by two-fold.

Therefore, there is a general consensus in the literature supporting the importance of preoperative health optimization, focusing on the control of blood glucose level.

Preoperative multidisciplinary approach must focus on optimizing the adjustable risk factors in the preoperative phase such as nutrition status, blood sugar level, cardiac and respiratory evaluation, and assessment for possible sources of infection and Methicillin-resistant *Staphylococcus aureus* (MRSA) decolonization (although universal screening for MRSA is not recommended). If MRSA colonization is suspected, short-term nasal application of mupirocin is the most accepted current method of decolonization for MRSA and/or MSSA.

All patients undergoing elective arthroplasty should be screened for evidence of active dental infection. This may be performed by administration of a questionnaire or dental examination.

Routine urine screening is not recommended for all patients undergoing elective arthroplasty and should be reserved for patients with a present history or symptoms of urinary tract infection (UTI).

It seems mandatory to stop the disease-modifying agents prior to elective TJA. The timing of drug cessation before surgery depends on the specific drug pharmacokinetics. The discontinuation of immunosuppressant drugs should be performed in consultation with the treating physician.

All patients with prior septic arthritis should undergo evaluation by serology and aspiration of the joint whenever possible, prior to arthroplasty. In addition to these preoperative assessments, by taking intraoperative cultures, the surgeons must ensure that no evidence of active infection exists.

## **5. Perioperative patient skin preparation**

Many reports have shown that a whole-body bath with an antiseptic agent reduces the bacterial load in the skin and lowers the risk of surgical site infections (SSIs).[34-37]

There is some evidence that applying chlorhexidine gluconate (CHG) twice daily by patients at home prior to TJA could significantly reduce the risk of SSIs.[41, 42]

So we recommend preoperative cleansing of the skin with CHG. In the presence of a sensitivity to CHG, or when it is unavailable, an antiseptic soap is appropriate. After bathing, patients are advised to sleep in clean garments and bedding without the application of any topical products.

The most proper method of hair removal is clipping, as opposed to shaving. There is not enough evidence to advise for or against the use of depilatory cream for hair removal. Literature recommends that hair removal should be performed as close to the time of the surgical procedure as possible.

There is no clear difference between various skin preparation agents. There is some evidence that combinations of antiseptic agents with alcohol may be important for skin antisepsis.

Elective arthroplasty should not be performed in patients with active ulceration of the skin in the vicinity of the surgical site. The incisions should not be placed through active skin lesions. For certain lesions, such as those due to eczema and psoriasis, surgery should be delayed in these patients until their lesions have been optimized.

## **6. Preoperative surgeon hand scrubbing**

The surgeon and operating room personnel should mechanically wash their hands with an antiseptic agent for a minimum of 2 minutes for the first case. A shorter period may be



appropriate for subsequent cases. There is no clear difference among various antiseptic agents for hand washing.

## 7. Preoperative antibiotics

There is a huge amount of evidence in the literature supporting the benefits of preoperative antibiotics in the prevention of PJI.[43-46]

Special care is required for selecting the prophylaxis antibiotic, consistent with the current recommendation of the literature. Patient allergies and resistance issues also need to be taken into account.

The aim of prophylactic antibiotics is to cover the spectrum of the most common organisms of PJI, Staphylococci, and Streptococci.

Therefore, a first- or second-generation cephalosporin (cefazolin or cefuroxime) should be administered for routine perioperative surgical prophylaxis. Isoxazolyl penicillin is used as an appropriate alternative. In a patient with a known anaphylactic reaction to penicillin, vancomycin, or clindamycin should be administered as prophylaxis. Teicoplanin is also an option in countries where it is available. In a patient with a reported non-anaphylactic reaction to penicillin, a second-, third- or fourth-generation cephalosporin can be used safely as there is limited cross-reactivity.

Skin testing in penicillin-allergic patients cannot reliably predict an allergic response to a cephalosporin, particularly to compounds with dissimilar side chains. However, skin testing may be useful in determining whether a true allergy to penicillin exists.

Penicillin has a cross-allergy with first-generation cephalosporins (OR 4.8; CI 3.7-6.2) and a negligible cross-allergy with second-generation cephalosporins (OR 1.1; CI 0.6-2.1). The R1 side chain, not the  $\beta$ -lactam ring, is responsible for this cross-reactivity. So the overall cross-reactivity between penicillin and cephalosporin is lower than previously reported (at 10%) although there is a strong association between amoxicillin and ampicillin with first- and second-generation cephalosporins that share a similar R1 side chain. For penicillin-allergic patients, the use of third- or fourth-generation cephalosporin or cephalosporins (such as cefuroxime and ceftriaxone) with dissimilar side chains than the offending penicillin carries a negligible risk of cross-allergy.

In patients with pre-existing prostheses, such as heart valves, the choice of antibiotics is the same as that for routine elective arthroplasty.

There is always a risk of colonization and infection development of vancomycin-resistant infections due to over-exposure to vancomycin. Routine use of vancomycin for preoperative prophylaxis is not recommended at all. Vancomycin should only be administered to patients who are proven current MRSA carriers or have anaphylactic allergy to penicillins.

The following patients are considered high risk for Methicillin-resistant *Staphylococcus aureus* (MRSA) carrying and should undergo screening:

- Those in regions with a high prevalence of MRSA
- Institutionalized patients (those who have been in the intensive care unit, nursing home residents, and dialysis-dependent patients)
- Healthcare workers

A point to consider is that vancomycin does not have full coverage on methicillin-sensitive *S. aureus*. Therefore, it should always be administered in combination with a cephalosporin.[52]

There is also no evidence to support the routine prophylactic use of dual antibiotics.

Asymptomatic patients with bacteriuria may safely undergo TJA provided that routine prophylactic antibiotics are administered. The presence of urinary tract symptoms should trigger urinary screening prior to TJA. Patients with acute UTI need to be treated prior to elective arthroplasty.

In patients with prior septic arthritis or PJI, the preoperative antibiotic should cover the previous infecting organism of the same joint.

The preoperative dose of antibiotics should be administered within one hour of surgical incision; for antibiotics with longer infusion time, such as vancomycin and fluoroquinolones, this time period should be extended to two hours. In case of tourniquet use, the antibiotic must be fully infused prior to tourniquet inflation. An additional dose of antibiotic should be administered intraoperatively after two half-lives of the prophylactic agent. Re-dosing of antibiotics should also be considered in cases of large blood volume loss (>2000 cc) and fluid resuscitation (>2000cc). As these are independent variables, re-dosing should be considered as soon as the first of these parameters are met.

Antibiotics have different pharmacokinetics based on patient weight, so the preoperative antibiotics should be weight-adjusted.

For current MRSA carriers, vancomycin or teicoplanin is the recommended perioperative antibiotic prophylaxis. Patients with prior history of MRSA should be re-screened preoperatively. If patients are proved to be negative for MRSA, the use of routine perioperative antibiotic prophylaxis is recommended.

For patients undergoing major reconstructions, such as tumor surgeries, revisions and reconstructions with bulk allograft, the use of routine antibiotic prophylaxis the use of routine perioperative prophylactic antibiotics is recommended.

In patients with poorly controlled diabetes, immunosuppression, or autoimmune disease the use of routine antibiotic prophylaxis is recommended.

Perioperative antibiotic prophylaxis should be the same for hips and knees arthroplasties.

The appropriate preoperative antibiotic for the second stage surgeries should include coverage of the prior organism(s).

Intraoperative considerations:

The probability of SSI correlates directly with the number of bacteria that reach the wound. The bacteria shed by personnel are the predominant source of these particles. Accordingly, any strategies to lower particulate and bacterial counts at surgical wounds will lower the incidence of SSI.

## 8. Operating room environment

Ultraviolet (UV) light can lower infection rates, but this modality can pose a risk to operating room (OR) personnel. However, the benefit of UV might be the inhibition of operating traffic. It might be considered an adjunct but not a replacement for conventional cleaning.

### 8.1. Laminar flow

Laminar airflow (LAF) was first introduced in the US in 1964. Positive air pressure is created in the surgical field via the directional airflow passing through higher-efficiency particulate air by vertical LAF and can help to reduce the incidence of PJI.[78-81] However, Brandt et al. state that LAF provides no benefits and even increases the risk of SSI after THA.

The LAF is often disrupted by the opening of the OR door, therefore giving pathogens an opportunity to enter the area around the operation site and increasing the risk of PJI.[67, 78, 83]

Nevertheless, there is still controversy about the pros and cons of LAF.[91]

The Centers for Disease Control and Prevention (CDC) has no comment supporting whether LAF may reduce the rate of SSI. There is no specific suggestion for performing arthroplasty procedures under LAF. Nonetheless, the CDC has published the following guidelines:

CDC Guidelines:[92]

1. Maintain positive-pressure ventilation with respect to corridors and adjacent areas.
2. Maintain  $\geq 15$  ACH, of which  $\geq 3$  ACH should be fresh air.
3. Filter all recirculated and fresh air through the appropriate filters, providing 90% efficiency (dust-spot testing) at a minimum.
4. In rooms not engineered for horizontal LAF, introduce air at the ceiling and exhaust air near the floor.
5. Do not use UV lights to prevent SSIs.
6. Keep OR doors closed except for the passage of equipment, personnel, and patients and limit entry to essential personnel.

Based on the current literature, arthroplasty surgery may be performed in operating theaters without laminar flow. Laminar flow rooms and other strategies that may reduce particulates in operating rooms would be expected to reduce particulate load. But the current evidence does not support the effect of LAF in reducing the incidence of SSI. These are complex technologies that must function in strict adherence to maintenance protocols.

Despite the absence of conclusive studies that show a reduction in SSI when surgical masks are worn properly and uniformly by all staff, adhering to this discipline is expected to reduce the particulate airborne bacteria counts. Until evidence appears that shows an advantage to not wearing a mask, all personnel should wear surgical masks at all time that they are in the OR.

All personnel wear clean theater clothes, including a disposable head covering, when entering an OR. Garments worn outside of the hospital should not be worn during TJA.

## 8.2. Gloving

Sterile surgical gloves have dual protection responsibilities; on one side it protects the patients from residual bacteria on the surgeon's hands, and on the other side protects the surgeon from the patient's body fluids.

Because double-gloving reduces the risk of perforation, it is highly recommended for orthopedic procedures, where sharp edges are commonly encountered during the surgery.[71-73]

Furthermore, some studies have shown that even double-gloving is not enough and inner gloves could have perforations and contamination. Accordingly, triple-gloving has been recommended during TJA to prevent the risk of contamination and PJI.[75, 76] However, triple gloving has some disadvantages, such as a decrease in tactile sensation and surgical dexterity.[77]

The Consensus on prevention of PJI recommends double gloving and recognizes the theoretical advantage of triple gloving.

The literature supports the advantage of glove changes at least every 90 minutes or more frequently and the necessity of changing perforated gloves. Permeability appears to be compromised by the exposure to methacrylate cement and gloves should be changed after cementation.

The current evidence shows that the timing of opening trays should occur as close to the start of the surgical procedure as possible with the avoidance of any delays between tray opening and the start of surgery.

Dummy Text **When** the surgical trays are not in use for an extended time, they should be covered with a sterile cover, preferably a small one to prevent the drape from passing from contaminated areas across the sterile field.

## 9. Human exhaust system (personal protection system)

In the 1960s, Sir John Charnley was the first to introduce the idea of the personal protection system (PPS), also known as the human exhaust system, in order to decrease the number of airborne bacteria and contamination in TJA.[93] There is currently no conclusive evidence to support the routine use of space suits in performing TJA. Major issues to consider regarding

PPSs are their bulkiness and susceptibility to contamination. In more than half of the cases, the PPS does not stay sterile externally. Therefore, it is advised that the PPSs not be touched during procedures, and if contact does occur, the gloves should be replaced.[98]

### 9.1. Operating room traffic

OR personnel, by traffic that creates turbulence and contaminates air and by bacterial shedding, are the major source of air contamination in the OR. Ritter et al. proved that in an OR with 5 personnel, the bacterial counts in OR air increased 34-fold compared to an empty room. Keeping the OR door open significantly increases bacterial contamination in the air of the OR. [17] Andersson et al. showed a direct correlation between the number of people present in the OR and bacterial counts. Some experts propose that passing through a sub-sterile hallway while entering or leaving the OR can increase the OR air contamination, although evidence regarding this concept is lacking. One possible solution to this is to keep the necessary devices and implants in the OR at the start of the surgery.

Another disadvantage of increased OR traffic is the distraction it causes for the surgeon.[106]

Therefore, based on the current literature, OR traffic should be kept to a minimum.

The CDC recommendation for OR traffic is to “keep OR doors closed except for the passage of equipment, personnel, and patients, and limit entry to essential personnel.”[92]

### 9.2. Draping

The literature supports the use of non-permeable paper drapes for draping the surgical site in TJA.[63-66]

Traditional cloth drapes tend to get wet during the surgery and could increase bacterial penetration; to that end, non-permeable paper drapes were introduced to overcome this issue. [63] Ritter et al. have presented that Ioban iodophor-impregnated drapes (3M Health Care) can reduce wound contamination but do not decrease the wound infection rate after TJA.[67]

The penetration of drapes by liquids is believed to be equivalent to contamination; therefore, literature recommends the use of impervious drapes.

Fairclough et al. showed that the rate of wound contamination during hip surgery was reduced from 15% to 1.6% after using plastic adhesive drapes.[68]

The efficacy of plastic adhesive drapes is optimum when the skin preparation is performed using alcohol-based solutions.

Theoretically, the plastic adhesive drapes can provide a sterile operative field at the beginning of the surgery and by immobilization of the bacteria underneath the drape, provide a long-term sterile field during the surgery and by these two, reduce the risk of surgical site contamination.

However, there are controversies about the effectiveness of plastic adhesive drapes in prevention of bacterial contamination.



As the current literature shows, iodine-impregnated skin incise drapes decreased skin bacterial counts but no correlation has been established with SSI.

The traditional practice of covering skin edges with sterile draping may be efficacious.

Light handles can be a source of contamination and literature recommends to minimize handling of lights as much as possible. Other strategies for light control need to be developed in the future to minimize contamination.

Portable electronic devices may be contaminated with bacteria. Besides, increased levels of talking are associated with higher levels of bacteria in the OR environment. Therefore, portable electronic device usage must be limited to that which is necessary for patient care.

The studies do not support the concern regarding risks of transferring infection to a clean surgery following a contaminated surgery. Therefore, when performing a TJA following a contaminated surgery, thorough cleaning before further surgery, as defined by local institutional standards, is recommended.

### 9.3. Operative time

SSI rates increase directly with the duration of surgery. Perhaps some surgeries present a marked level of complexity that will require more time. But minimizing the duration of surgery is an important goal. To achieve this goal, a coordinated effort must be made to minimize the duration of surgery without technical compromise of the procedure.

The rate of PJI tends to be inversely proportional to the surgeon's volume of surgeries, the lower the surgeon volume, the higher the risk of infection. This seems to be especially statistically significant after TKA. [104]

Literature shows high contamination rates in the scalpel blades that have been used for the skin incision and recommends change of scalpel blade after skin incision.

Since there is no evidence, the literature cannot recommend for or against the necessity and frequency of change of electrocautery disposable tips during elective TJA.

In contrast to electrocautery tip, literature supports changing suction tips every 60 minutes based on studies showing higher rates of contamination. Suction tips can be introduced into the femoral canal to evacuate fluid but should not be left in the canal, where they can circulate large amounts of air and particles that may contaminate femoral canal.

Studies confirm that the use of fluid filled basins that sit open during the surgery is associated with increased infection rates.

There is at least some theoretical basis for irrigation to dilute contamination and nonviable tissue and that a greater volume of irrigation would be expected to achieve greater dilution. However, literature cannot support any recommendation for one method over another. The only proved mechanism of action for irrigation is the mechanical effect of the solution. But there exists conflicting evidence supporting the use of one agent over the other.



## 10. Wound closure and surgical dressing

Numerous techniques such as skin staples, absorbable sutures, and knotless barbed sutures are used for skin closure in TJA. Despite the lack of evidence supporting the superiority of one technique of skin closure over others (staples, suture, adhesive, or tapes), the use of monofilament suture for wound closure is recommended to decrease the SSI. Literature does not support the effect of staples on decreasing the rate of SSI.

The kind of dressing applied after the procedure may have an essential role in the wound healing process.[120, 121] The re-epithelization and collagen synthesis rates are increased in wounds that have the wound dressing applied to them when compared to wounds that are allowed to be exposed to air.[122, 123]

Following TJA, the use of occlusive dressings with alginate hydrofiber is strongly recommended. Silver-impregnated dressings have not been conclusively shown to reduce SSI/PJI.

Persistent wound drainage after TJA is defined as continued drainage from the operative incision site for greater than 72 hours. This persistent wound drainage should be managed by wound care. According to various studies, the first line treatment for persistent wound drainage is nonsurgical management prior to surgical intervention. Other treatment modalities, such as antibiotics, are highly discouraged because they can mask an underlying infection. Since the cause and effect relationship between persistent wound drainage and PJI has been proven, observation alone is strongly discouraged.[17, 21, 24, 26] One of these measures is negative pressure wound therapy (NPWT), which has proved to decrease the size of postoperative seromas.[27]

It is discouraged to use greater than 24 hours of postoperative antibiotics to treat persistent wound drainage after TJA because there is no evidence that it decreases PJI.[18, 20]

If wound care measures are not effective and the wound drainage has persisted for greater than 5 to 7 days from the time of diagnosis, reoperation should be performed without delay. The surgical management should consist of opening the fascia, performing a thorough irrigation and debridement (I&D) with exchange of modular components. When performing I&D, intraoperative cultures (minimum of three) should be taken. In these situations, the administration of perioperative antibiotics given within one hour prior to I&D reoperation should not be withheld prior to skin incision.

As literature shows, allogeneic blood transfusions is associated with an increased risk of SSI/PJI. However, the role of autologous transfusion in the risk of SSI/PJI remains inconclusive. The female gender, higher Charlson comorbidity index, use of general anesthesia, and longer duration of surgery are predictors of the potential need for allogeneic blood transfusion in patients undergoing TJA. There is no defined benefit for the use of cell salvage systems, reinfusion drains, bipolar sealers, and hemodilution for management of PJI.

There is no evidence to demonstrate that the use of closed drains increases the risk of SSI/PJI following TJA. And there is no conclusive evidence for the optimal timing of drain removal yet.

The evidences show that blood salvage should be utilized with caution during the second stage surgery for PJI.

The literature supports that the type of prosthesis (cemented versus uncemented) or coating with hydroxyapatite does not influence the incidence of SSI or PJI. However, antibiotic-impregnated polymethylmethacrylate cement (ABX-PMMA) reduces the incidence of PJI following TJA and should be used in patients at high risk for PJI following elective arthroplasty, whether in primary or revision arthroplasties.

Observational data suggest that metal-on-metal bearing may be associated with a higher risk of PJI.

The bulk of prosthesis has a direct effect on the incidence of PJI. The incidence of infection is higher following the use of mega-protheses.

The incidence of SSI/PJI may be lower with the use of porous metal (tantalum) implants during revision arthroplasty compared to titanium.

There is no study in the literature to prove that adding the vancomycin powder to the wound in the vicinity of an implant can reduce the incidence of PJI. This effect of vancomycin has been shown in nonarthroplasty surgeries in a few studies.

## 11. Postoperative antibiotic prophylaxis

Postoperative antibiotics should not be administered for greater than 24 hours after surgery. In patients with a suspected infection when culture results are pending, empiric antibiotic coverage, depending on the local microbiological epidemiology, should be continued until the results of culture are ready. Then, the antibiotic choice and timing should be based on the culture data.

Recommendations:

- Until final cultures become available, we recommend to treat the acute hematogenous infections with cefazolin and gentamicin.
- We recommend vancomycin to treat all chronic and acute postoperative infections with gram-positive bacteria and all cases in which a gram stain fails to identify.
- The recommended antibiotics for infections with gram-negative bacteria are third or fourth generation cephalosporin.
- The recommended regimen to treat the infections with mixed gram-positive and gram-negative bacteria is a combination of vancomycin and third or fourth generation cephalosporin.
- As 93% cultures tested positive by the fourth postoperative day, the authors recommend that if culture results are not positive by the fourth postoperative day, termination of empiric antibiotic therapy should be considered. But the culture must continue for 14 days.

There is no evidence to support the continued use of postoperative antibiotics when urinary catheter or surgical drains are in place.

As mentioned earlier PJI can occur any time after the surgery. Episodic bacteremia could be a potential risk for PJI and certain medical procedures are more likely to cause bacteremia. Therefore, in 2012, the American Academy of Orthopaedic Surgeons (AAOS) released a new guideline on “The Prevention of Orthopaedic Implant Infections in Patients Undergoing Dental Procedures.” It has three main recommendations:[126]

1. “The practitioner might consider discontinuing the practice of routinely prescribing prophylactic antibiotics for patients with hip and knee prosthetic joint implants undergoing dental procedures.”
2. “The guideline does not recommend for or against the use of topical oral antimicrobials in patients with prosthetic joint implants or other orthopaedic implants undergoing dental procedures.”
3. “Although there is not reliable evidence linking poor oral health to prosthetic joint infection, it is the opinion of the work group that patients with prosthetic joint implants or other orthopedic implants maintain appropriate oral hygiene.”

The evidence shows that the use of prophylactic antibiotics prior to dental procedures in patients who underwent TJA should be based on individual patient risk factors and the complexity of the dental procedure.

Furthermore, in cases of viral infection, it is recommended that there is no role for oral antibiotics, even for patients at higher risk.

The literature confirmed that for other minor surgical procedures such as endoscopy and colonoscopy, transient bacteremia could be minimized by administration of prophylactic antibiotics, especially in high-risk patients.[127]

## 12. Conclusion

PJI is a serious complication with significant morbidity and mortality. Several factors in the pre-, intra-, and postoperative phases are involved that can predispose a patient to PJI. It is always better to focus on prevention rather than treatment. One of the most important preoperative factors to reduce the risk of PJI is optimization of the patient's health. Administration of preoperative prophylactic antibiotics should always be considered. It is crucial to follow the recommendations of the Consensus on the prevention of PJI to minimize the risk of infection intraoperatively. Finally, patients who undergo TJA are always at risk of infection; therefore, it is very important to prescribe prophylactic antibiotics prior to certain medical procedures.

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