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Proceedings of the International Consensus Meeting on Periprosthetic Joint Infection

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(Eighth Section: Operative Environment)

Question 1: Do numbers of bacteria arriving in the surgical wound correlate directly with the probability of surgical site infection (SSI)?

Consensus: We recognize that the probability of SSI correlates directly with the quantity of bacteria that reach the wound. Accordingly we support strategies to lower particulate and bacterial counts at surgical wounds.
Delegate Vote: Agree: 97%, Disagree: 2%, Abstain: 1% (Strong Consensus)

Justification: Postoperative SSIs are believed to occur via bacterial inoculation at the time of surgery or as a result of bacterial contamination of the wound via open pathways to the deep tissue layers.[1-3] The probability of SSI is reflected by interaction of parameters that can be categorized into three major groups.[2] The first group consists of factors related to the ability of bacteria to cause infection and include initial inoculation load and genetically determined virulence factors that are required for adherence, reproduction, toxin production, and bypassing host defense mechanisms. The second group involves those factors related to the defense capacity of the host including local and systemic defense mechanisms. The last group contains environmental determinants of exposure such as size, time, and location of the surgical wound that can provide an opportunity for the bacteria to enter the surgical wound, overcome the local defense system, sustain their presence, and replicate and initiate local as well as systemic inflammatory reactions of the host.
The use of iodine impregnated skin incise drapes shows decreased skin bacterial counts but no correlation has been established with SSI. However, no recommendations regarding the use of skin barriers can be made (See Question 27).

Question 2: Do numbers of bacteria in the operating room (OR) environment correlate directly with the probability of SSI?

Consensus: We recognize that airborne particulate bacteria are a major source of contamination in the OR environment and that bacteria shed by personnel are the predominant source of these particles. The focus of our recommendations is to reduce the volume of bacteria in the OR with particular attention to airborne particles.
Delegate Vote: Agree: 93%, Disagree: 5%, Abstain: 2% (Strong Consensus)

Justification: Air is a potential source of contamination in the OR.[2, 4] Studies have demonstrated that the number of airborne bacteria around the wound is correlated to the incidence of periprosthetic joint infection (PJI).[1] It has been suggested that if it was possible to measure accurately the number of bacteria present in the wound it should constitute the most precise predictor of subsequent infection.[5] Bacteria can be considered as part of the total mass of particulates in the air. Some studies have suggested that the airborne particulate count should be considered as potential surrogate for airborne microbial density.[6] Others have found a correlation between the number of particulates larger than 10 micrometers with the density of viable bacteria at the site of surgery (measured by colony forming units).[7] It has been suggested that monitoring particulate count be used as a real-time proxy for increased risk of wound contamination or infection.[7] Persons in the OR are a major source of bacterial load and shed bacterial particulates. These particulates circulate through the OR via air currents. Movements of personnel and objects (including OR equipment) and opening and closing doors can generate significantly marked air currents and increase the probability of bacteria being deposited in the surgical site.[3, 8]

Question 3: Should the OR in which an elective arthroplasty is performed be fitted with laminar air flow (LAF)?

Consensus: We believe that 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. Studies have not shown lower SSI in laminar flow rooms and some cases are associated with increased rates of SSI. These are complex technologies that must function in strict adherence to maintenance protocols. We recommend further investigation in this field.
Delegate Vote: Agree: 85%, Disagree: 7%, Abstain: 8% (Strong Consensus)

Justification: The most cited studies supporting the use of LAF were conducted in the 1970s and 1980s by Charnley and Lidwell et al.[9, 10] However, several recent studies have shown no clear benefit of LAF in reducing the incidence of deep SSI.[11-14] Breier et al. conducted a nationwide study in Germany, controlling for confounding factors with multivariate analysis, and found no independent effect of LAF on SSI rates, even when considering LAF rooms with large ceiling sizes (at least 3.2m x 3.2m).[11]
A recent study by Hooper et al. that was based on the New Zealand joint registry evaluated the subject on a wide basis.[13] The authors analyzed 51,485 total hip arthroplasties (THA) and 36,826 total knee arthroplasties (TKA) and revealed increased early infection rates with laminar flow use, especially for THA patients. This increase was found to be independent of patient characteristics, operative time, surgeon, or institution. Unfortunately, except for the study performed by Salvati et al. in which horizontal LAF was found to increase the risk of PJI in TKA, other studies, including those supporting the use of LAF,[10] those opposing its use,[13] and those with indifferent results,[15-17] did not conduct any subanalysis to distinguish influence of different types of LAF on PJI.

Question 4: Is there enough evidence to enforce the universal use of body exhaust suits during total joint arthroplasty (TJA)?

Consensus: There is currently no conclusive evidence to support the routine use of space suits in performing TJA.
Delegate Vote: Agree: 84%, Disagree: 11%, Abstain: 5% (Strong Consensus)

Justification: Similar to the situation with laminar flow, the use of space suits during TJA has become a subject of controversy. A recent study by Miner et al. showed no benefit in the use of body exhaust suits[14] and a study by Hooper et al. evaluating the use of a space suit and its effect on early infection rates identified an increased rate of early infection with the use of space suits both in conventional and in laminar flow theaters.[13] However, there is some suggestion that space suits should be worn in laminar flow-fitted rooms to prevent contamination.[18, 19]

Question 5: What strategies should be implemented regarding OR traffic?

Consensus: We recommend that OR traffic should be kept to a minimum.
Delegate Vote: Agree: 100%, Disagree: 0%, Abstain: 0% (Unanimous Consensus)

Justification: Personnel are the major source of air contamination in the OR, both by traffic that creates turbulence and contaminates ultraclean air and by bacterial shedding. Ritter et al. showed that bacterial counts in OR air increased 34-fold in an operating room with 5 people compared to an empty room.[17] Keeping the OR door open also significantly increased bacterial air contamination of the room in the same study. Andersson et al. showed a positive correlation between traffic flow rates and air bacterial counts in orthopaedic procedures.[15] They also identified a direct correlation between the number of people present in the OR and bacterial counts. Quraishi et al. further demonstrated a direct correlation between the activity level of OR personnel and bacterial fallout into the sterile field. [20] Panahi et al. observed door openings during primary and revision TJA cases.[21] They identified 0.65 and 0.84 door openings per minute in primary and revision cases, respectively. The main personnel responsible for door openings were implant technical representatives and circulating nurses. Lynch et al. showed an exponential relationship between the number of door openings and the number of personnel in the OR. In their series, information requests (an easily avoidable cause) was the reason for the majority of door openings.[22] Multiple door openings can result in a drop in the pressure gradient requiring more air being pumped through LAF systems and therefore the high efficiency particulate air filters are consumed more quickly. It has been proposed by experts that OR personnel pass through a sub-sterile hallway every time they enter or leave the OR, although evidence regarding this practice is lacking. If preoperative templating is possible, available sizes of the implants should be in the OR at the start of the surgery.

Question 6: Should operating lights be controlled with a foot pedal as opposed to reaching above eye level?

Consensus: We recommend a general awareness that light handles can be a source of contamination and to minimize handling of lights as much as possible. Other strategies for light control need to be developed in the future to minimize contamination.
Delegate Vote: Agree: 91%, Disagree: 4%, Abstain: 5% (Strong Consensus)

Justification: Davis et al. identified a 14.5% rate of contamination of sterile light handles during TJA cases.[23] Hussein et al. showed no evidence of contamination of the sterile light handle (autoclaved plastic or metallic) after 15 cases of primary TJA.[24] However, we were unable to identify other studies in the literature addressing the risk of contamination of the surgeon's gown or of parts of the sterile field when compared with reaching up for light adjustment, or studies that looked at air disruptions secondary to the movement of the surgeon reaching above eye level.

Question 7: Is there a role for ultraviolet (UV) light use in the prevention of infection after TJA?

Consensus: We agree that UV light environments can lower infection rates, but recognize that this can pose a risk to OR personnel. We recognize that the benefit of UV might be the inhibition of operating traffic.
Delegate Vote: Agree: 74%, Disagree: 13%, Abstain: 13% (Strong Consensus)

Justification: Even though UV light use has been shown to significantly decrease the number of bacterial counts in the OR, as well as the occurrence of postoperative infection, its use is harmful for OR personnel and increases the risk of corneal injuries and skin cancer; as such, current guidelines from the Centers for Disease Control (CDC) recommend against the use of UV lights in the OR to prevent SSIs.[5, 25-30]

Question 8: Do UV decontamination/sterilization lights or portable units in unoccupied ORs (nights and weekends) make a difference in the sterility of the OR environment?

Consensus: UV would be expected to lower bacterial load in ORs, but the technology has not been studied in this application. It might be considered an adjunct but not a replacement for conventional cleaning. There are potential risks to staff by UV technology inadvertently left on at the start of the work day.
Delegate Vote: Agree: 84%, Disagree: 3%, Abstain: 13% (Strong Consensus)

Justification: After a thorough literature search, we were unable to identify evidence to support or refute the use of UV light to keep the OR environment sterile outside operative times.

Question 9: Should the patient and OR personnel wear a mask to avoid contamination of the OR air?

Consensus: Despite the absence of conclusive studies that show a reduction in SSI when surgical masks are worn properly and uniformly by all staff, we believe there is reason to expect particulate airborne bacteria counts to be reduced by disciplined use of surgical masks. Until evidence appears that shows an advantage to NOT wearing a mask, we believe that it is in the interest of patient safety that all personnel wear surgical masks at all time that they are in the OR. There is insufficient evidence to support the use of masks by patients that outweighs the benefit of airway access.
Delegate Vote: Agree: 85%, Disagree: 7%, Abstain: 8% (Strong Consensus)

Justification: Several authors have questioned the utility of face masks worn by OR personnel in preventing air and wound contamination.[31-33] A study by Lipp and Edwards included 3 randomized controlled trials (RCTs)with a total of 2,113 subjects and concluded that the use of face masks had no significant effect on surgical wound infections in patients undergoing clean surgery.[32] Sellden et al. decided to refrain from the use of face masks for unscrubbed personnel in the OR.[34] A recent RCT by Webster et al. showed that if none of the non-scrubbed OR personnel wore a face mask, there was no increase in the rate of SSIs. However, this study included non-orthopaedic as well as orthopaedic procedures and followed patients for only 6 weeks postoperatively.[35] Furthermore, it was not clear if orthopaedic procedures included implantation procedures. We were unable to identify studies looking specifically at face masks worn by the patient undergoing TJA or studies evaluating the benefit of this practice in reducing OR air contamination.

Question 10: What garments are required for OR personnel?

Consensus: We recommend that all personnel wear clean theater attire including a disposable head covering, when entering an OR. Garments worn outside of the hospital should not be worn during TJA.
Delegate Vote: Agree: 98%, Disagree: 1%, Abstain: 1% (Strong Consensus)

Justification: Some aspects of the appropriate attire for surgical personnel (such as surgical gowns and gloves) have been addressed in other sections. Controversy has been raised regarding the utility of surgical masks or head coverings in the prevention of SSI based on inconsistent results from experimental and clinical investigations in the field of general surgery, gynecology, and cardiology (cardiac catheterization).[36-42] Nevertheless, as affirmed by CDC guidelines,[28] use of surgical masks by all OR personnel is an advantageous and harmless behavior that provides a mechanical obstacle for OR personnels' oro- and nasopharyngeal secretions. These secretions may contain bacterial particulates and all efforts should be made to decrease the risk of exposure of surgical wound to these particulates. Moreover, masks can also be beneficial in protecting the personnel from patients' blood or other bodily fluids.

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