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Review article

Preventing surgical-site infections: Measures other than antibiotics

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ABSTRACT

Surgical-site infections (SSIs) due to intra-operative contamination are chiefly ascribable to airborne particles carrying microorganisms, mainly *Staphylococcus aureus*, which settle on the surgeon's hands and instruments. SSI prevention therefore rests on minimisation of airborne contaminated particle counts, although these have not been demonstrated to correlate significantly with SSI rates. Maintaining clear air in the operating room classically involves the use of ultra clean ventilation systems combining laminar airflow and high-efficiency particulate air filters to create a physical barrier around the surgical table; in addition to a stringent patient preparation protocol, appropriate equipment, and strict operating room discipline on the part of the surgeon and other staff members. SSI rates in clean surgery, although influenced by the type of procedure and by patient-related factors, are consistently very low, of about 1% to 2%. These low rates, together with the effectiveness of prophylactic antibiotic therapy and the multiplicity of parameters influencing the SSI risk, are major obstacles to the demonstration that a specific measure is effective in decreasing SSIs. As a result, controversy surrounds the usefulness of many measures, including laminar airflow, body exhaust suits, patient preparation techniques, and specific surgical instruments. Impeccable surgical technique and operating room behaviour, in contrast, are clearly essential.

The prevention of surgical-site infections (SSIs) is an integral component of nosocomial infection control and a major priority in orthopaedic surgery. Surgical wound contamination must be prevented to avoid patient colonisation by microorganisms during surgery. In addition to prophylactic antibiotic therapy, SSI prevention involves maintaining an aseptic operating room (OR) environment and impeccable OR discipline on the part of all staff members. The effectiveness of preventive measures is influenced by the quality of the patient's immune defences and type of surgical procedure.

1. Epidemiology of surgical-site infections (SSIs)

The incidence of SSIs in orthopaedic and trauma surgery varies with the level of risk associated with each type of procedure, as assessed using the Altemeier classification (Table 1); general health of the patient (ASA class) (Table 2); and National Nosocomial Infections Surveillance (NNIS) risk index based on the contamination class, ASA class, and operative time (Table 3). SSIs occur in less than 1% of low-risk patients, who account for most scheduled joint replacement procedures. In contrast, SSIs may develop in up to 15% of high-risk patients undergoing contaminated procedures, a situation encountered chiefly in emergency trauma surgery [1–3].

2. Contaminants

2.1. Source of surgical-site infections (SSIs)

The contaminating microorganisms may be endogenous or exogenous. The skin is a source of endogenous microorganisms, and optimal preoperative skin preparation is therefore essential. Exogenous microorganisms are vectored by airborne particles, the staff (hands, other areas of the skin, and mucous membranes) or, more rarely, inanimate objects (instruments, material, furnishing, or irrigation solutions) [4]. The patient's skin is the direct source of contamination in only 2% of cases, leaving 98% of cases related to airborne particles [5]. Surgical-site contamination by airborne particles is ascribable in 30% of cases to direct settling of the particles on the wound and in 70% of cases to settling on the instruments and surgeon's hands followed by transfer to the wound [6]. Thus, surgical-site contamination is chiefly attributable to airborne particles, some of which may carry microorganisms. Given this predominant role for airborne contamination, air quality in the OR deserves close attention.

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Table 1
Contamination classes according to Altemeier et al.

Contamination classes	Classification
Class I, clean surgery (SSI risk < 1%)	The surgical procedure involves a normally sterile area of the body. The skin is initially intact. If drainage is required, a closed system must be used The surgical procedure does not involve opening of the gastro-intestinal, respiratory, genito-urinary, or oro-pharyngeal tract
Class II, clean-contaminated surgery (SSI risk 2–5%)	The procedure involves opening the gastro-intestinal, respiratory, or genito-urinary or oro-pharyngeal tract under tightly controlled technical conditions and in the absence of abnormal contamination (i.e., urine or bile is sterile)
Class III, contaminated surgery (SSI risk 5–10%)	Massive surgical-site soiling by gastro-intestinal lumen contents, opening of the genito-urinary or biliary tract in a patient with urinary or biliary tract infection. Recent open traumatic wounds
Class IV, dirty or infected surgery (SSI risk > 10%)	Surgical procedure involving a body site that contains pus, foreign bodies, or faeces. Traumatic wounds created more than 4 hours earlier This definition suggests the presence of microorganisms responsible for SSI in the surgical-site the before the operation

Altemeier WA, Burke JF, Puitt BA, Sandusky WR. Manual on control of infection in surgical patients. JB Lippincott 2nd Ed, Philadelphia, 1984, p 29.

Table 2
American Society of Anesthesiologists (ASA) preoperative assessment classification.

ASA classification	Preoperative assessement
I	No health condition other than that requiring surgery
II	Mild abnormality in a major function
III	Severe abnormality in a major function
IV	Disease that is a constant threat to life
V	Moribund patient

2.2. Characteristics of airborne particles

Airborne particles come from multiple sources, of which the most relevant is the shedding of squames or skin scales. On average, an individual having a moderate level of physical activity sheds about 10 min^{-1} particles measuring at least 0.5 mm in diameter. Despite their large size, squames circulate via the convection currents created by the temperature gradient between the body and the environment [7]. Other sources of airborne particles include dust and condensation droplets measuring less than 5 μ in diameter and representing the remnants of larger droplets produced during coughing, talking, and suction systems.

Particle size influences the tendency to settle on surfaces. Particles smaller than 5 μ remain suspended in the air, those larger than 100 μ settle rapidly, and those of intermediate size (5–100 μ) may settle on potentially contaminated surfaces then migrate to another sites. Particles may carry variable bacterial loads, depending on their source.

Particle production and mobilisation vary according to the number of individuals in the OR. Another factor is whether the surgical attire constitutes an effective barrier against the shedding of squames into the OR air: thus, squames may migrate from sites of uncovered skin (e.g., neck and forearms) or through gaps in the material used to make surgical garments (e.g., 80 μ for woven cotton) [8]. Any movement in the OR can mobilise particles. Airborne particle counts are highest at the beginning of the operation because patient installation requires displacements and other movements of the personnel [9]. The many other sources of particles include the use of a cautery, which produces fine and ultrafine particles, and the use of saws or drills [10].

Controlling airborne particle circulation requires careful attention to OR discipline, surgical technique, and operative time. Air can act not only as a reservoir, but also as a vector for the transmission of bacteria via particles (e.g., dust and squames) or condensation droplets smaller than 5 μ.

Contamination by airborne microorganisms plays a central role in the pathogenesis of SSIs. Prevention of contamination by airborne microorganisms requires knowledge of the most commonly encountered microorganisms and of their dissemination characteristics. In addition, familiarity with air quality parameters, air quality measurement tools, and air treatment methods is crucial.

Table 3
National Nosocomial Infections Surveillance risk index (NNIS).

Variables	Codification
Contamination class	0, clean or clean-contaminated 1, contaminated or dirty
ASA class	0, patient in normal health or with mild systemic disease 1, patient with severe or incapacitating systemic disease or moribund patient
Operative time	0, time shorter than the T point 1, time equal to or longer than the T point The T point is the time that represents the 75th percentile of similar procedures in the NNIS database The NNIS risk index is computed as the sum of the codes for the three variables and can therefore range from 0 to 3

The NNIS risk index is based on three variables (contamination class, ASA class, and NISS value) scored as described below. Garner JS. CDC guideline for prevention of surgical wound infections. Revised. Infect Control 1985;7:193–200, 1986.

3. Air quality control

3.1. Nature of contaminants

The microorganisms most often responsible for SSIs are *Staphylococcus aureus*, with 40% to 70% of cases [1,11], followed by coagulase-negative staphylococci and Gram-negative bacteria. These bacteria exhibit considerable resistance to exogenous insults (which allows them to survive while airborne) and are consequently associated with a high-risk of transmission (AFNOR classification of the pathogenic potential of microorganisms, from 1 to 4).

Bacteria measure 0.2 to 5 μ. They can adhere to particles, preferably those of greater size, to form larger aggregates known as colony-forming units (CFUs, measured per m^2). Hansen et al. reported a statistically significant correlation between counts of particles larger than 5 μ and counts of bacterial colonies. Thus, all particles measuring 5 to 10 μ can be considered potentially infected [10].

Measures that decrease airborne particle counts are central to diminishing the risk of contamination by airborne microorganisms.

3.2. Air quality parameters

Several parameters are used to assess OR air quality:

- the airborne particle count at rest is used to classify ORs according to an ISO standard. Orthopaedic ORs must meet the ISO 5 criterion, namely, < 3500 particles/m^3 (Table 4). A limitation to this

Table 4
ISO classification of air particle concentration.

ISO class	Maximal acceptable concentrations (per m^3) of particles equal to or greater than the sizes listed below					
	0.1 μm	0.2 μm	0.3 μm	0.5 μm	1 μm	5 μm
4	10,000	2370	1020	352	83	
5	100,000	23,700	10,200	3520	832	29
6	1,000,000	237,000	102,000	35,200	8320	293
7				352,000	83,200	2930
8				3,520,000	832,000	29,300

classification is that the measurements are made when the OR is not being used and no individuals are present;
- the degree of microbial contamination, i.e., the CFU count per m^3 of air determined by injecting air samples into nutrient agar then identifying and counting the colonies. Charnley and Eftekhar, as well as Lidwell concluded that counts lower than 10 CFU/m^3 were mandatory for hip and knee arthroplasty [12]. The count should probably be less than 1 CFU/m^3 to eliminate all risk of airborne contamination [10]. Nevertheless, the tolerable bacterial count is not universally agreed on. It has been set at 5 CFU/m^3 in France versus 35 CFU/m^3 in the UK and 25 CFU/m^3 in Switzerland for conventional ORs [11,13].

3.3. Air treatment methods

Air quality depends on the air treatment methods used. Relevant factors are the air delivery and filtration system, characteristics of OR air changes, and existence of positive pressure compared to adjacent locations.

3.3.1. Air delivery and filtration systems

The goal is to create a dynamic barrier around the at-risk area by generating a guided flow of filtered air that carries the particles away while ensuring a satisfactory air change rate [5,14]:

- air filtration: currently available filters stop particles larger than 0.5 μ;
- airflow: three categories can be distinguished:
  - turbulent flow: the air is delivered through outlets located on a wall and aspirated by exhausts on an opposite wall. This system creates non-parallel air flows, most notably at the instrument tables and surgical-site (Fig. 1),
  - two types of unidirectional flow: the air moves through a given volume and in a single direction through a clean room or area, in parallel flows and at a uniform rate. The flow may be either horizontal or vertical and either partial (confined to the surgical table surface) or total (encompassing the entire OR) (Fig. 2).

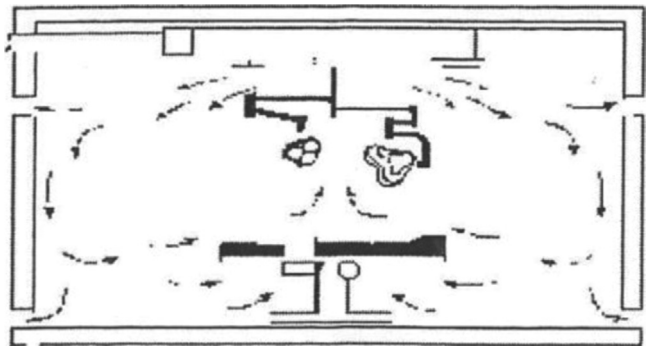

Fig. 1. Turbulent airflow.
From P. Vichard.

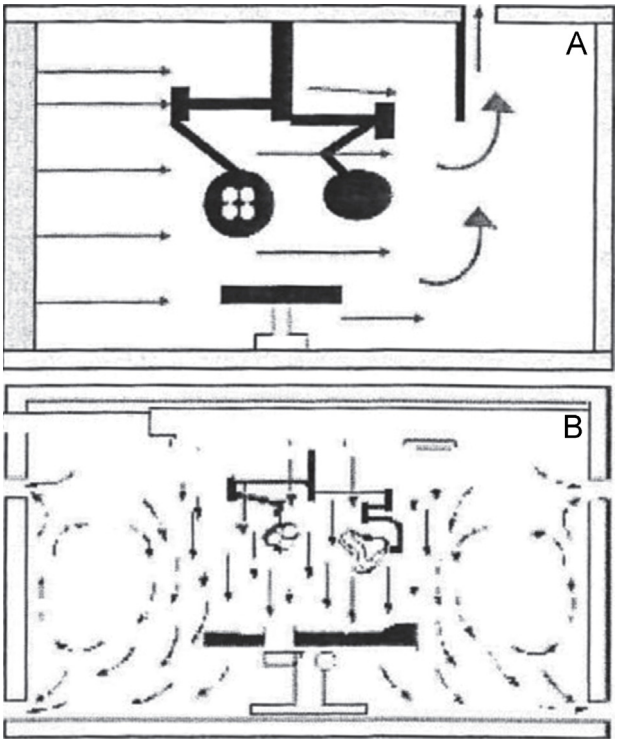

Fig. 2. Unidirectional horizontal flow/Unidirectional vertical flow.
From P. Vichard.

Various airflow rates are used:

- rates close to or greater than 0.50 m/s are required to obtain a downwards laminar flow at the surgical-site, around the area at greatest risk;
- rates lower than 0.25 m/s create a stabilised flow (Fig. 3).

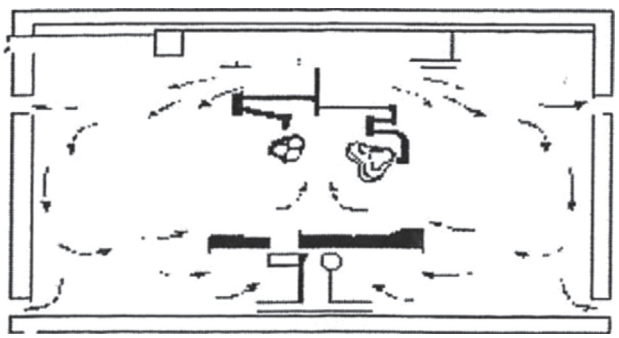

Fig. 3. Stablised airflow.

3.3.2. Air changes

Another important parameter is the air change rate, assessed as the number of air changes per hour. The smallest acceptable value is 20% of the total air volume per hour. The size of the ceiling air outlets is important to consider. The volume of fresh air depends on both the surface area of these outlets and the rate of delivery. An excessively small surface area requires a high delivery rate, which generates levels of noise that are difficult to tolerate [15].

3.3.3. Positive pressure

An adequate and stable increase in air pressure (of at least 15 Pa) in the OR relative to adjacent sites is required to limit turbulence during door openings.

3.3.4. Particle decompression kinetics

This parameter is defined as the time required to return a specific room loaded with dust particles (according to pre-defined criteria) to 90% of the particle count measured with the ventilation system on.

Air quality in the OR during surgery depends on the combination of air treatment measures (filtration, delivery, changes, and positive pressure) with crucially important personnel-related factors (number of individuals in the OR, surgical attire, and behaviours).

4. Methods for preventing surgical-site infections (SSIs)

4.1. Limitations

Mean SSI rates are very low after clean surgery: 0.9% (range, 0.7–2.6% depending on the NNIS index) in total hip arthroplasty (THA) and 0.6% (range, 0.4–2.3%) in total knee arthroplasty (TKA) [13]. These very low rates constitute a major obstacle to the demonstration of a statistically significant effect of preventive measures.

In practice, a major issue is whether the contaminated particle count and, therefore, the number of bacteria that settle on the surgical-site dictate the SSI rate or not. A simple and direct relationship linking the surgical-site bacterial count (which depends on the number of airborne bacteria carried by particles) to the SSI rate may seem to make intuitive sense. Such a relationship would mean that a high particle count indicates a high-risk of SSI. However, although surgical-site bacterial counts correlate with airborne bacteria and particle counts, they have not been demonstrated to correlate with the SSI risk.

This fact is related to the multiplicity of factors that influence the SSI risk, including the nature and virulence of the bacteria, quality of the patient's immune defences, and type of surgical procedure, which can modify local conditions, most notably by promoting the development of a local inflammatory response. Furthermore, prophylactic antibiotic therapy is routinely administered and significantly decreases the SSI risk. Our current surgical methods combine numerous preventive measures derived from recommendations and everyday practice. As a result, evaluating the specific effect attributable to a given measure in isolation is extremely difficult, particularly as conflicting data have been published.

4.2. Laminar flow

Since Charnley, who did not use prophylactic antibiotic therapy, the use of a laminar airflow system has long been considered crucial to the prevention of SSIs. Lidwell reported that a unidirectional vertical airflow decreased the SSI rate by 50% after THA or TKA. Vichard confirmed this beneficial effect, with a number of caveats [14]. The French Society for Hospital Hygiene (Société Française d'Hygiène Hospitalière, SF2H) and French-Speaking Society for Infectious Diseases (Société de Pathologie Infectieuse de Langue Française, SPILF) reached a strong consensus in 2004 and 2009, respectively, regarding the ability of OR ventilation by a laminar air flow to decrease the SSI risk compared to a non-unidirectional air flow when performing clean surgical procedures (Class I), such as joint prosthesis implantation.

Recent studies have challenged this position. Laminar airflow failed to provide benefits in some studies [6] and increased the early SSI rate in others [15,16]. A systematic literature review by Gastmeier et al. that collected data from over 75,000 TKAs and 120,000 THAs indicated that using a laminar airflow system significantly increased the SSI risk, which was nearly doubled for THAs [17]. These discrepancies are ascribable to the heterogeneity of available studies, in which laminar airflow was combined with many other preventive measures. In addition, using laminar airflow may give a false sense of security leading to lapses in the application of other precautions [18]. For instance, the area covered by the laminar airflow may fail to extend to the instrument table. Other potentially deleterious factors include positioning of the OR staff members in a way that alters the direction of airflow and cooling of exposed tissues by the airflow. The use of devices secured directly to the patient's limb near the incision and delivering a powerful unidirectional flow to a small volume was suggested recently [19].

In the absence of detailed research protocols having a stronger focus on air treatment, the use of laminar airflow during prosthesis implantation should continue to be advocated, even in the absence of corresponding recommendations.

4.3. Patient preparation

Preparation of the surgical-site in the OR makes a crucial contribution to SSI prevention. This well-standardised measures cannot be separated from the overall preparation of the patient.

At a 2004 consensus conference held by the French Society for Hospital Hygiene, a number of recommendations were issued.

Preparation of the patient should include at least showering (with an antiseptic detergent solution) on the day before and morning of the operation, without hair removal, provided this measure does not interfere with surgical requirements.

In the OR, the patient's skin should be cleansed with an antiseptic detergent solution, rinsed with sterile water, dried, and liberally painted with antiseptic, preferably two coats of an alcoholic solution.

Given the absence of proof that showering with an antiseptic solution and application of a detergent decreased the SSI risk, patient preparation measures were reappraised in 2013. Nevertheless, the beneficial effects of skin preparation before entering the OR have been convincingly demonstrated [20]. Thus, in patients undergoing emergency THA after a hip fracture, skin microorganism counts before detergent skin cleansing in the OR were 3 times higher than in patients undergoing scheduled hip arthroplasty with skin preparation on the day before surgery [21].

The current tendency is to simplify the skin preparation protocol. No recommendations can be made about the following points:

- number of preoperative showers, type of cleansing agent (antiseptic or non-antiseptic), or usefulness of a shampoo; however, at least one preoperative shower is advisable, provided it is performed very shortly before surgery;
- nail polish removal when the fingers or hand (or the toes and foot) are not included in the surgical field;
- use of topical chemical depilatory agents: hair removal is not among the preventive measures for SSIs and should not be performed routinely; in addition, shaving with a mechanical razor should be banned;
- application of a detergent before the antiseptic agents when the skin is not soiled;

- selection of the antiseptic agent (chlorhexidine or povidone-iodine) or the usefulness of successively applying two antiseptics belonging to different classes. Nevertheless, preference should be given to alcohol-based antiseptic agents. Small studies suggest that chlorhexidine alcohol may be more effective than iodinated agents with or without alcohol in diminishing skin microorganism counts [22].

Nasal carriage of *S. aureus* is often cited among factors likely to increase the risk of air contamination during clean orthopaedic surgery. However, routine screening and decolonisation are not currently recommended, except in the following two situations:

- when the rate of SSIs due to *S. aureus* is abnormally high (greater than 2% despite the usual SSI prevention measures);
- when scheduled surgery is to be performed in a patient previously hospitalised in an intensive care unit or intermediate- or extended-care facility or in a patient with chronic skin lesions.

4.4. Surgical staff preparation and patient installation

4.4.1. Hand hygiene

Substantial changes in hand hygiene practices have occurred over the last decade, most notably with the introduction of alcohol-based hand rubs. Classic hand hygiene products include povidone-iodine, alcohol-based solutions, and chlorhexidine gluconate.

Alcohol-based solutions produce the largest decreases in hand bacteria counts, with sustained results after 3 hours. Nevertheless, the presence of glycerol in the formulation may result in the shedding of small sticky agglomerates produced by a reaction between the skin cells and glycerol in the moist environment within the gloves [23]. Strict compliance with instructions for using these products, particularly regarding brushing and the duration and extent of rubbing, is mandatory. The optimal duration of antiseptic product application seems to be at least 2 minutes, after washing with soap for at least 2 minutes, with a separation between hand washing and antiseptic product application.

4.4.2. Operating room (OR) attire

Many studies have sought to define the optimal OR attire. The results are mixed and at times controversial, and they should be interpreted according to the type of surgical procedure, i.e., contaminated emergency surgery or joint replacement surgery. Here, we will focus on clean (Class I) surgical procedures.

A number of points are well established:

- special garments should be worn in the OR. However, the usefulness of surgical masks, hoods covering the hair (a major location for staphylococci), and shoe covers during conventional surgical procedures has been challenged [24]. OR garments should optimally be sealed by elastics at the waist, ankles, neck, and wrists to avoid the shedding of skin squames;
- the surgical staff should wear disposable impermeable garments made of non-woven fabric, which should be tightened depending on the material used (polypropylene or Gore-Tex) [25].

Laminar airflow produces air eddies that mandate the use of fairly loose masks and hoods. Tight masks and hoods rub against the skin, thereby increasing the shedding of contaminated particles. Their use in combination with laminar airflow may result in 3- to 5-fold increases in CFU/m^3 values and in a nearly 60-fold increase in the number of settled bacteria [24]. When combined with laminar airflow, a total body suit was not superior over a conventional disposable non-woven gown [25] in decreasing air contamination [6]. The only benefit from the suit was improved protection of the staff from splashes of blood or other body fluids. Similarly, filtered exhaust suits incorporating a self-contained ventilation system were not more effective than conventional surgical masks [22,26]. Furthermore, Shaw et al. suggested that the increased temperature around the face might promote bacterial growth and that the increased pressure within the suit might increase the dissemination of bacteria if the seal between the helmet and gown was not fully effective [27]. Thus, body exhaust suits with incorporated air ventilation systems do not seem mandatory, even for prosthetic surgery. In addition, consideration should be given to surgeon discomfort related to the suit.

4.4.3. Gloves

Double gloving is mandatory but does not dispense from full compliance with hand washing technique. Perforation of the glove in direct contact with the skin occurs in 15% of cases with single gloving compared to only 5% with double gloving [28]. Furthermore, perforation of the outermost glove has been noted in 3.7% of primary prosthetic surgery procedures and 8.3% of revision procedures; unrecognised perforations of the innermost glove were found in 19% of cases. In orthopaedic surgery, glove perforation occurs consistently, after a mean of 90 minutes [22]. The relative discomfort related to wearing two pairs of gloves is considered acceptable by 92.2% of orthopaedic surgeons [28]. The gloves should be changed at least every 90 minutes, although a shorter interval is undoubtedly preferable [29].

The gloves should be changed before performing the incision, as 12% of gloves are contaminated after draping and 24% once patient installation is complete.

A glove change is also required before touching the implants and after cementation, since the gloves may become permeable after contacting cement [12].

Triple gloving, with a resistant liner between two pairs of gloves, impairs dexterity to an unacceptable degree.

4.4.4. Draping

Impermeable, disposable, non-woven drapes deserve preference. The use of plastic film impermeable to bacteria is intended to prevent microorganism migration after draping but it is not the focus of any of the current recommendations. Neither are recommendations available regarding the usefulness of antiseptic-impregnated drapes or films compared to those without antiseptics [20,22].

4.5. Conduct of the surgical procedure

4.5.1. Discipline

Many factors require attention, most notably those capable of distracting the surgical team. Antoniadis et al. found a mean of nearly 10 interruptions or distractions per hour during 65 procedures in a range of surgical specialities, with 25% of these events being related to personnel entering or exiting the OR and 25% to calls from cell phones or beepers [30]. The introduction of computers, tablets, radios and, above all, cell phones into the OR is a potential source of contamination. Among these devices, 44% to 98% carry resistant microorganisms (Gram-negative rods and *S. aureus*). Therefore, the introduction of portable electronic devices into the OR is best avoided, and when their use is mandatory, they should be thoroughly cleansed using an alcohol-related solution before they are taken into the OR [22].

4.5.2. Foot traffic in the operating room (OR)

Airborne particle counts increase with the number of people in the OR and, above all, with their movements and the number of door openings, which affect the direction of air circulation [8]. Door opening rates of 13 to 40 per hour have been reported during prosthesis implantation procedures. In a study by Andersson et al.

[8], 7% of door openings were related to unexpected events pertaining to the surgical procedure; 26% to a need for material, indicating suboptimal preoperative planning and preparation; and 27% to the entry of people who had no role in the surgical procedure. There is strong agreement that the number of people in the OR should be kept at 5 or 6 at the most to ensure that the airborne bacterial count does not exceed 10 CFU/m^3 [31].

4.5.3. Preparation of the surgical table

Surgical table preparation should be coordinated with draping, which is the step at greatest risk for particle contamination. The surgical table should not be prepared until patient installation is complete, given the 4-fold increase in airborne contamination during patient installation.

Containers and instruments must remain covered. The duration of instrument tray opening correlates directly with the contamination rate (4% after 30 minutes, 15% after 1 hour, and 30% after 4 hours [32]).

4.5.4. Operative technique

The operative technique should be as gentle as possible. Excessive traction on the tissues, which can induce local ischaemia and inflammation must be avoided. Careful haemostasis is mandatory. These measures depend in large part on the surgeon's level of discipline and experience.

4.5.5. Position of surgical lights

The lights should not be placed directly above the surgical field. Manual handling of lights should be minimised during the procedure to avoid creating turbulence in the laminar airflow; reduce the need for surgeon movements, which increase particle shedding; and decrease the risk of contaminating sterile light handles.

4.5.6. Intra-operative irrigation

Regardless of the modalities (volume, solution with or without antiseptic agents or antibiotics, high or low pressure), intra-operative irrigation has not been proven effective in non-contaminated surgery.

4.5.7. Wound closure and drainage

The use of monofilaments has not been proven beneficial. Absence of drainage is increasingly recommended, as well as early drain removal after 24 hours [33].

4.5.8. Patient-warming

In gastro-intestinal surgery, maintaining normothermia is a recognised means of decreasing the SSI risk.

The use of forced air warming mattresses has been criticised as disrupting the laminar airflow and increasing airborne bacterial counts. In orthopaedic surgery, however, no correlation with the SSI rate has been demonstrated [34].

4.5.9. Operative time

A longer operative time has been shown to increase the SSI risk. The increase occurs when the operative time is above the 75th percentile. In a study, of 56,216 primary TKAs, Namba et al. found a 9% increase in the SSI risk for each 15-minute increase in operative time [35]. When interpreting this finding, the possibility that a longer operative time may reflect intra-operative complications or greater procedural complexity should be taken into account.

4.5.10. Order of patients in the operating room (OR)

No studies have established that the SSI risk is increased when a clean procedure is performed after a contaminated procedure, provided the OR is decontaminated using a well-standardised protocol between patients [22]. Nevertheless, contaminated procedures are best performed at the end of the OR schedule, and surgical staff must comply with individual decontamination procedures to prevent staff-to-patient transmission of microorganisms.

5. Conclusion

Intra-operative SSI prevention rests on a combination of multiple measures. The considerable efficacy of routine prophylactic antibiotic therapy prevents the demonstration of statistically significant effects of each individual measure. In orthopaedic surgery, the general consensus is that useful measures include laminar airflow, impermeable surgical garments covering most of the body (with a mask, a hood, and shoe covers), and non-woven drapes. Nevertheless, these measures have been challenged. SSI prevention requires strict OR discipline with careful attention to every detail that might result in contamination.

The surgeon should understand that the SSI risk also depends in large part on the quality of the patient's immune defences. Consequently, the preoperative evaluation must detect all factors capable of impairing immunity (e.g., comorbidities, drugs, and addictions). The influence of these factors on the SSI risk needs to be studied and taken into account when evaluating the appropriateness of the surgical procedure. In addition, it should be fully disclosed to the patient.

Disclosure of interest

The author declares that he/she has no conflicts of interest concerning this article.

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