1.14. PREVENTION: OPERATING ROOM, SURGICAL FIELD

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QUESTION 1: When should instrument trays be opened during surgery to minimize the risk of contamination?

RECOMMENDATION: Instrument trays should be opened as close to the time of surgery as possible. Once opened, trays and instruments should be covered with a sterile towel or drape when not in use.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 97%, Disagree: 2%, Abstain: 1% (Unanimous, Strongest Consensus)

RATIONALE

The importance of airborne bacterial contamination of surgical incisions in the operating room has been appreciated for decades [1–4]. Pasquarella et al. [5] demonstrated airborne particles in the orthopaedic arthroplasty operating room (OR) to be a source of contamination for early surgical site infections (SSIs). Surgical instruments tend to be contaminated during the procedure by airborne particles and microbes, allowing surgical instruments to act as fomites even if the surgical field is not grossly contaminated [6]. Post-sterilization contamination of sets containing surgical instruments has been shown to increase the rate of deep SSIs in orthopaedic patients [7].

Airborne contamination in the OR is not constant throughout the perioperative period. Brown et al. [8] demonstrated that bacterial air counts during antiseptic preparation and draping of the patient were 4.4 times higher than during surgery, leading them to recommend opening instruments after patient preparation and draping have been completed. Chauveaux et al. [9] also noted a four-fold increase in airborne contaminants during the preparation of the limb and draping of the patient and recommended against opening of instruments until after the patient has been fully draped.

Two manuscripts clearly address the time-dependent contamination rate of orthopaedic instruments. Dalstrom et al. [10] opened trays in an OR and left the instruments exposed to the environment without an ongoing procedure, but with light traffic. They reported a time-dependent rate of contamination in opened trays, with 4% of trays contaminated by 30 minutes compared to 30% of trays contaminated after 4 hours of exposure. Trays opened and then subsequently covered with a sterile towel were protected from contamination ($p = 0.02$). Although this finding does not give a clear guideline for how long a sterile tray can be exposed to the open environment before the contamination risk becomes unacceptable (i.e., causes surgical wound infections), the authors demonstrated a direct correlation between the exposure times of open instrument trays and the risks of bacterial contamination. Coverage of the implants with a sterile towel mitigated the risk to a significant degree. Bible et al. [11] demonstrated similar protection from contamination with a sterile towel, but have contradicted the time-dependent contamination rate. Covered implants were less likely to be contaminated prior to implantation versus those that were uncovered (2 vs. 16.7%,) in their study. The simple, practical step of covering the surgical tray with a sterile towel significantly reduced the contamination risk. Therefore, no matter the expected duration of a case, implant tray coverage is a simple way to reduce the risk of contamination once a tray has been opened.

Based on the limited available data, a moderate conclusion can be made. Instrument trays should be kept in sterile packaging and opened only after the patient has been prepped and draped. Additionally, instruments should be opened as close to the time that they will be used in the procedure as possible, as there is a time-dependent contamination rate of instruments opened and exposed to the operating room environment.

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QUESTION 2: Does the use of a splash basin increase contamination of instruments and the rate of subsequent surgical site infections/periprosthetic joint infections (SSIs/PJIs) in patients undergoing orthopaedic procedures?

RECOMMENDATION: Unknown. We recommend against the use of fluid-filled splash basins that sit open during surgery based upon microbiological contamination data. However, the independent association between splash basin contaminations and developments of subsequent SSIs/PJIs remain unclear.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 91%, Disagree: 4%, Abstain: 5% (Super Majority, Strong Consensus)

RATIONALE

The use of a splash basin (a utensil filled with sterile water) in the operating room (OR) aims to provide a place to wash, store and clean surgical instruments of debris before potential reuse during an orthopaedic case. While some recommendations for surgical technologists and OR staff continue to reinforce its use [1,2], several published studies have shown evidence of bacterial contamination in these basins, with rates between 2.2 and 74.4% reported [3–8].

In a randomized controlled trial, Lindgren et al. examined the rates of positive cultures from aliquots of splash basin fluid containing either sterile water (n = 47) or a solution of 0.05% chlorhexidine (n = 53), following primary joint arthroplasties [8]. Bacterial growth in samples obtained from splash basins was 9% in the sterile water group versus 0% in the chlorhexidine solution group (p = 0.0045). Secondary analysis of early wound complications at six weeks following surgery revealed higher rates of SSIs in the sterile water basin group (6.4 vs. 1.9%), however this trend did not reach statistical significance (p = 0.339) due to inadequate statistical power.

Four prospective observational studies have also identified bacterial growth within operative splash basins [3,4,6,7]. In a consecutive series of elective orthopaedic cases, Andersson et al. showed that 13 out of 21 (61.9%) irrigation solutions stored in basins were contaminated at the end of the procedure. The colony forming units (CFUs) seen in these positive cases ranged from 8.3 to 226.5 CFUs/L with mainly *Staphylococcus epidermidis* or diphtheroid rods identified [7]. Baird et al. revealed a contamination rate of 74.4% in specimens sampled from splash basin fluids after randomly-selected orthopaedic procedures (n = 78). In their series, 59% of the positive fluid cultures had polymicrobial signal and 12% showed counts of > 100 CFU/100 ml [4]. Similarly, Anto et al. demonstrated a 23.8% rate of bacterial contamination in liquid samples removed from splash basins [3]. The mean number of instruments placed within the basin was 46 (range 12 to 74). Coagulase-negative staphylococci were found to be the most common contaminating organism. No patients with contaminated samples developed features of superficial or deep surgical site infection at the minimum six-month follow-up in their series.

In contrast, Glait et al. found lower rates of bacterial contamination in samples taken from splash basins that were used to wash and store instruments in a series of 46 primary hip or knee arthroplasty cases. Only 1 case out of 46 (2.2%) tested positive for bacterial growth [5]. However, this study used a single swab of the basin for culture testing as opposed to the basin fluid aliquots used in all other studies, which make account for their conflicting observations. Furthermore, in a larger series of 87 TJAs using swabs placed in transport mediums prior to culture, Jonsson et al. showed that splash basins were the most commonly contaminated site. They found that 12 of 87 basin swabs (24.1%) tested positive on culture. Again, intraoperative contamination could not be correlated to clinical infections on long-term follow-up. The authors posit that a larger study group with multivariate analysis may be able to define this independent effect of intraoperative contamination [6].

In further contrast to the wider body of literature suggesting basins are a possible source of contamination, surgical technologists have often been trained to use these basins as a means of instrument decontamination and thus may still encourage their use in the OR [1]. The Association of Surgical Technologists recommends that “a basin of sterile water should be available in the sterile field for the soaking and cleaning of instruments” [1]. In addition, Beauclair et al. recently suggested the importance of using a sterile water basin for “moisturization and removal of bioburden from reusable surgical instruments” [2]. The Association of Perioperative Registered Nurses along and Association of Surgical Technologists have also previously recommended the use of a splash basin to keep reusable instruments clean and moist after wiping them down [2]. However, these recommendations are largely in contrast to multiple reports regarding the culture contamination seen in splash basins.

In summary, several studies have confirmed positive bacterial growth of the fluid from the operative splash basin [3–8], and suggest that this may be a source of intraoperative contamination. However, conclusions regarding the direct association between intraoperative contamination in splash basins and subsequent SSIs/PJIs remain unclear [6]. Nevertheless, in the fight against orthopaedic infections, every possible source of bacterial contamination should be eliminated [9]. We, therefore, advocate that splash basins should be abandoned from the OR until more evidence is available.

Isolated reports also suggest that filling splash basins with a dilute antiseptic solution such as chlorhexidine gluconate or dilute betadine, rather than sterile water, may have a role in reducing rates of microbial contamination in basins [8,10,11].

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QUESTION 3: Does changing the electrocautery tip during surgery reduce the rate of subsequent surgical site infections/periprosthetic joint infections (SSIs/PJIs)?

RECOMMENDATION: While it is clear that electrocautery tips may become contaminated during surgery, no study has been able to prove a relationship between the amount of time that an electrocautery tip is exposed and its contamination. However, in cases where there is known infection, such as a one-stage or two-stage exchange arthroplasty for PJI, we do recommend changing the electrocautery tip at the end of the "dirty" portion of the procedure and prior to reimplantation of components.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 92%, Disagree: 5%, Abstain: 3% (Super Majority, Strong Consensus)

RATIONALE

Aseptic techniques are fundamental to the prevention of SSIs and PJIs. It is well-known that sterile surgical equipment can be contaminated intraoperatively, including gloves, gowns, light handles and even instruments that are introduced directly into the wound, such as suction catheter tips [1–6]. Certain recommendations have even been put forth regarding surgical equipment that have the potential to contaminate the surgical site, such as suction tips [7].

Electrocautery is frequently utilized during orthopaedic procedures for soft tissue dissection and obtaining hemostasis. Contamination of electrocautery tips was first noted in the dermatology literature. *Staphylococcus aureus* was shown to transfer from tissue to sterile tips and vice versa [8]. Shahi et al. performed the first study, examining the contamination of electrocautery tips in orthopaedic surgeries [9]. Electrocautery tips were collected from 25 primary total hip arthroplasties (THAs) and 25 aseptic revision THAs and were inoculated in cultures. Five unused electrocautery tips were also inoculated into cultures as negative controls. Cultures isolated an organism in 4% of electrocautery tips from primary THAs and 8% of tips from aseptic revision THAs. No organisms were isolated from the unused and clean tips. Thus, the rate of positive cultures was twice as high in the revision THA group [9].

While revision THA is known to take longer than primary THA, there was no association between electrocautery tip exposure time and contamination rate in the latter study. Conversely, a similar study conducted by Abdelaziz et al. looking at both primary and revision hip and knee arthroplasties, revealed a higher rate of electrocautery tip contamination in their primary arthroplasty cohort [10]. In this study, the authors reported a 10% rate of electrocautery tip contamination for the primary arthroplasty group and 4% for the aseptic revision cohort. All negative controls in this study also failed to isolate an organism on culture. This study also failed to show an association between duration of exposure of the electrocautery tip and subsequent contamination [10]. Furthermore, they noted a high rate of contamination (15/50, 30%) of the electrocautery tips in septic revisions.

In conclusion, electrocautery tips are vulnerable to contamination during surgery. However, the importance of such contamination is questionable. Larger, adequately-powered studies with sufficient follow-up to determine if this contamination is a source of subsequent SSIs/PJIs are needed but may be difficult to perform due to the large sample sizes needed for adequately powered SSIs/PJIs samples. Given the high rates of contamination noted during septic cases, changing the electrocautery tips prior to implantation of components is recommended.

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QUESTION 4: Should suction tips be regularly changed during surgery? If so, how frequently?

RECOMMENDATION: Yes. The suction tips should be regularly changed during surgery. Although no time threshold has been established for its exchange, we believe it should be changed every 60 minutes. Studies have shown that suction tips get contaminated during surgery and the contamination rate is higher with prolonged operative time.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 85%, Disagree: 9%, Abstain: 6% (Super Majority, Strong Consensus)

RATIONALE

Contamination of the suction tip during surgical procedures has been reported [1–7]. This occurs either by airborne bacteria because of the large volume of air passing through the suction tip, by direct contamination of the tip by contact with patient's skin or by improper handling by operating team members. In the orthopaedic field, several studies reported contamination rates of suction tips as high as 37 to 65% in conventional/non-laminar air operating theaters [4,6–8] and 4.6 to 41% in ultra-clean/laminar flow operating theaters [2,5]. *Staphylococcus* species (coagulase-negative and epidermidis) were the dominating contaminants isolated from suction tips, comprising 34 to 100% of cases [1,2,4–8] .

Only one study, by Givissis et al., reported a patient that developed a deep wound infection with the same microorganism responsible for contaminating the suction catheter tip [4]. No other study was identified showing an association between contamination and deep or superficial infection. Furthermore, two studies showed relationships between the duration of use, and the contamination rates of suction tips. Greenough et al. [6] reported a 37% (11/30) contamination rate after a median of 82 minutes of operating time (suction usage), compared to a 3.3% (1/30) rate after a median duration of 17 minutes of suction usage. Givissis et al. [4] showed that in surgeries lasting less than 1 hour, suction tip cultures were positive only in 1 out of 11 (9.1%), compared to 26 out of 39 (66.7%) when surgery operative times exceeded 1 hour.

When analyzing studies from different surgical fields, considerably greater contamination of suction tips was also noted. Laham et al. [9] analyzed general contamination in public and private general operating rooms and observed suction tip contamination in 13.33% of cases. Larson et al. [10] evaluated suction catheter contamination during aortic valve replacement surgery and showed contamination rates from 48 to 52%. McMaster et al. [11] found a contamination rate 21% of suction tips used in Cesarean deliveries. In non-orthopaedic surgery, main contaminants isolated from suction tips were also *Staphylococcus* species (coagulase-negative) comprising up to 76% of cases [9,10].

Multiple authors recommend changing the suction tip/catheter during prolonged surgeries or before critical steps of surgery (preparing femoral canal or cementing components) and turning off the suction when it is not in use [2–7,12]. However, there are concerns that turning off the suction might impose risk of contaminations of the surgical field due to backflow of the material along the suction tube and tip. Therefore, we think that suction device should be turned on as late as possible to minimize the risk of airborne contamination. Because of the high contamination rates and plausible bacterial seeding to operating wound, use of suction tips as a probe, retractor or pointer during surgery should be actively discouraged.

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QUESTION 5: Should suction tips enter the intramedullary canal during orthopaedic surgery?

RECOMMENDATION: Suction tips can be introduced into the intramedullary canal during orthopaedic surgery to remove fluid as needed, but should not be left in the canal where they draw in large volumes of ambient air and particles that could potentially contaminate the intramedullary canal.

LEVEL OF EVIDENCE: Consensus

DELEGATE VOTE: Agree: 91%, Disagree: 4%, Abstain: 5% (Super Majority, Strong Consensus)

RATIONALE

It has been suggested that the suction catheter tip may be contaminated and act as a reservoir for microorganisms [1,2]. As such, contact between the suction tip and any area of the surgical field is likely to lead to contamination and serve as a nidus for later infections. Unnecessarily keeping the suction catheter in the intramedullary canal can draw ambient air into the intramedullary canal, where it can deposit bacteria and increase the risk of subsequent infection. However, there are no studies to support this theoretical concern and one may never expect to obtain or generate real-world clinical data to examine this issue.

Greenough et al. [3] found a 37% rate of contaminated operative suction tips used in total hip arthroplasties (THAs). However, when evaluating the suction tips used only for cleaning the femoral shaft, only one of 31 suction tips were contaminated. As such, the authors advised changing the suction tip before preparing the femur in THA. The same conclusion was drawn by Robinson et al. [1] who conducted a similar study among patients undergoing THA and identified a 41% contamination rate of suction tips. Insull et al. [4] presented a lower rate of contamination of 7.8%, but the authors did not report on the use of the suction tip in the intramedullary canal.

Strange-Vognsen et al. [5] reported a contamination rate of 54% for suction tips used for THA. However, among the 12 culture-positive suction tips, 9 grew coagulase-negative staphylococci, which is a common culture contaminant [6]. Therefore, it is possible that a significant number of the culture-positive suction tips could represent false-positive results. The authors advised that the suction be turned on only when in use, however, there are concerns of backflow of suction container content when turned off [7].

Givissis et al., [8] studied 50 patients who underwent trauma procedures during which suction was used and found contaminated suction tips in 27 cases (54%). The duration of the operative procedure appeared to be an important variable influencing suction tip catheter contamination. The tip was contaminated in only 1 out of 11 procedures lasting less than 1 hour (9.1%), as compared to 26 out of 39 (66.7%) when operative times exceeded 1 hour. However, deep wound infection was recorded in only one case. It appears that operative lengths of more than one hour increases the risk of suction catheter contamination, raising it seven-fold from 9.1 to 66.7%.

When assessing the clinical relevance of these studies, it is important to know that contamination of a suction catheter tip at the completion of surgical procedure does not necessarily equate to infection [8]. As such, there is lack of evidence addressing the issue of suction tip contamination and subsequent infection. There is little data related to the influence of using the suction tip inside the medullary canal and the potential for subsequent infection.

In the absence of conclusive evidence, drawing on the data that shows suction tips are contaminated in a large number of cases lasting more than one hour, we recommend that suction tips not be inserted into the medullary canal except for removal of blood and to obtain the necessary visualization. Efforts should be made not to leave the suction tip inside the medullary canal, as this carries the theoretical risk of introducing ambient air and particulate bacteria into the canal.

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