Intraoperative Issues

Perfusion/Oxygenation

The prevention of SSI hinges on meticulous surgical technique, assessment and melioration of modifiable host factors, and evidence-based antibiotic prophylaxis. Both local factors, such as the degree of contamination of the wound, and system factors, such as the overall condition of the patient, influence the rates of wound infections.1

Cellular processes involved in wound healing depend on adequate perfusion and oxygenation. Inadequate perfusion and tissue hypoxia may result in tissue ischemia, which can cause the release of plasminogen activators, thereby stimulating fibrinolysis, causing delayed or impeded wound healing. It also reduces the number of bacteria required to cause an infection, and may influence the function of other organs and, thus, the patient’s susceptibility to infection. Attention must be given to conditions such as hypoxic lung disease and atherosclerosis, which increase the patient’s risk for development of a surgical site infection.2

Hypothermia may contribute to vasoconstriction and tissue hypoxia.1 Tissue perfusion can be improved by maintaining normal hemodynamic status, by decreasing intraoperative blood loss, and by keeping the patient normothermic. Local tissue perfusion can be enhanced by avoiding vasoconstrictive agents, when possible, and by the gentle handling of tissue.2

Several studies have examined the effect of high inspiratory oxygen on the rate of SSIs. It has been hypothesized that the detrimental effects of tissue hypoxemia can be prevented or minimized by administering supplemental inspired oxygen to the patient during the perioperative period. However, the evidence is conflicting, and whether high FiO2 should become the standard intervention for surgical operations remains to be seen.3-8

Hypothermia

Hypothermia (defined as body temperature below 96.8° Fahrenheit or 36° Celsius) may result from general anesthesia or from prolonged exposure to cold, which is common during the perioperative period, if the patient is not actively warmed. According to the American Society of Anesthesiology Practice Guidelines for Postanesthetic Care, normothermia should be a goal during emergence and recovery, and forced-air warming systems should be used to prevent hypothermia.9
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Anesthesia causes peripheral vasodilation, predisposing the patient to hypothermia. During anesthesia, heat is lost through radiation, evaporation, convection, and conduction.\textsuperscript{10} The original measure addressing hypothermia in the Surgical Care Improvement Project (SCIP) focused solely on colectomy patients. However, in October 2009, it was expanded to apply to all patients undergoing surgical procedures under general or neuraxial anesthesia for at least 60 minutes. The measure, endorsed by the NQF, sets parameters for maintaining normothermia before, during, and after surgery.\textsuperscript{11}

Surgery, and especially general anesthesia, change the normal balance between heat loss and production by depressing the hypothalamic thermoregulatory center.\textsuperscript{12} Furthermore, normal thermoregulation, particularly through vasoconstriction and shivering, is inhibited during anesthesia, resulting in hypothermia being an adverse effect of both general and regional anesthesia.\textsuperscript{13} Despite national initiatives to prevent surgical hypothermia, it remains a common but avoidable scenario in the operating room.

Consequences of Hypothermia

Failure to prevent perioperative hypothermia has profound negative consequences for the patient, including increased postoperative discomfort; surgical bleeding and requirement for allogeneic blood transfusion; wound infection; and morbid cardiac events.\textsuperscript{12}

Intraoperative hypothermia causes a reduction in peripheral circulation, which may, in turn, lead to tissue hypoxia and make the wound more susceptible to infection, even if contamination levels are low.\textsuperscript{14}

Risk of SSI and a prolonged hospital stay are increased for hypothermic patients, as evidenced by research on colorectal cancer surgery. Increased risk of superficial incisional SSI results from mild hypothermia, which causes vasoconstriction, decreased delivery of oxygen to the wound space, and subsequent impairment of the immune function.\textsuperscript{15-17}

Hypothermia can also increase blood loss and the need for transfusion during surgery. In vitro studies indicate that perioperative hypothermia may aggravate surgical bleeding by impairing the function of platelets and clotting factors. Additionally, blood transfusion may increase susceptibility to surgical wound infection by impairing the immune function.\textsuperscript{16}

Inadvertent hypothermia also causes several physiological changes.\textsuperscript{13}

Techniques to Prevent Hypothermia

The normal core temperature should be maintained during surgery through the use of active warming techniques, such as forced-air warming blankets, warmed intravenous (IV) fluids, and ambient
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temperature control. Although warmed IV fluids, alone, will not warm the patient, they may effectively prevent the onset of hypothermia. Keeping patients warm prior to entering the operating room suite has proven to facilitate the maintenance of normothermia during the operative procedure. Adjustment of operating room ambient temperature to the range of 68° to 77° F (20°-25° C)11, or 68° to 73° F (20°-23° C) if the facility is required by code to adhere to the American Institute of Architects (AIA) guidelines, also helps alleviate intraoperative hypothermia.10

Given the numerous adverse effects of hypothermia, it is imperative for members of the perioperative team, including the anesthesia provider and surgeon, to be proactive in the thermal regulation of their patients. Maintaining proper ambient operating room temperature, minimizing blood loss through meticulous surgical technique, and decreasing surgical time will assist in keeping the patient normothermic.12

Use of forced-air warming blankets can be effective in maintaining the patient’s core temperature and should be routinely applied during both laparoscopic and open operations. The use of fluid warmers for intravenous fluid also prevents fluid-induced hypothermia.12 There is some evidence to suggest that a 30-minute preoperative period of warming before the surgery reduces infection rates from 14% to 5%.14

Intraoperative Wound Management

Excellent surgical technique contributes to surgical safety and the avoidance of SSI. Elements of a good surgical technique include maintaining effective hemostasis while preserving adequate blood supply, gentle handling of tissues, and proper use of drains and sutures.15

Intraoperative wound management characterized by asepsis, hemostasis, and gentle handling of tissues increases the likelihood of a good surgical outcome.18 Rigorous adherence to the principles of asepsis by all scrubbed personnel, as well as those who work in close proximity to the sterile field, such as the anesthesiologist and the circulating nurse, is paramount to SSI prevention.15

Whenever possible, surgical dissection should generally be performed along avascular tissue planes. The goal of the surgical dissection is to isolate structures of interest from surrounding tissue, while causing the least amount of trauma and bleeding, and preserving the viability of the tissues that will be left in place.19 Debride devascularized tissues to eliminate this medium for bacterial growth.2 Use of electrocautery, even in cutting mode, rather than a scalpel may cause greater necrosis and devitalization of a larger tissue area.

When using a self-retaining retractor, the surgeon should carefully observe for tension and pressure on tissues. Handling tissues with fingers is often not as gentle as using instruments and may transmit contamination to the wound through nicks and breaks in gloves.18 During the surgical procedure, exposed subcutaneous fat and muscle tissue should be covered with moist sponges to prevent desiccation, trauma, and contamination.18
Intraoperative Issues (continued)

Prevention of SSI is critical to ensure normal wound healing. Evidence demonstrates that the main source of wound contamination is endogenous, and the role of the perioperative staff is to minimize the patient’s exposure to contaminants.\textsuperscript{20}

**Hemostasis**

A thorough preoperative history and physical examination of the patient should include an assessment and evaluation of any bleeding disorders and of the patient’s overall risk of intraoperative bleeding.\textsuperscript{1}

Hemostasis depends on interactions among circulating proteins (coagulation factors and inhibitors), cellular elements (platelets and white blood cells), and vascular endothelium and smooth muscle. In the early stages of hemostasis, platelets rapidly adhere and aggregate at the site of the vascular injury to form a platelet plug. A fibrin network reinforces the platelet plug and provides a frame for fibroblastic in-growth and ultimate healing of the injury.\textsuperscript{1}

The use of local hemostatic agents may improve hemostasis and reduce complications related to hemorrhage. A variety of local hemostats, including absorbable gelatin sponge, collagen hemostat, and oxidized cellulose are available. Local hemostats are applied when cautery, ligature, clips, or other conventional hemostatic methods are impractical, or when a larger tissue surface requires hemostasis.\textsuperscript{21}

However, local hemostats function as a foreign body,\textsuperscript{2} and excess or saturated hemostatic agents should be removed from the operative field where possible, as their hemostatic utility may be superseded by their potential to be a nidus for infection.

**Blood Transfusion**

Blood loss during surgery increases the risk of surgical site infection. Evidence supports that excessive perioperative blood loss that necessitates transfusion is associated with increased risk of surgical site infection after a variety of operations.\textsuperscript{22} Transfusion of leukocyte-containing allogeneic blood components during the perioperative period also increases the risk of SSI.\textsuperscript{15} The association between allogeneic blood transfusions and an increased risk for infection at multiple sites, including wound infection, suggests a system-wide immune response to the transfusion.\textsuperscript{23-25} A significant risk factor that necessitates perioperative transfusion and the use of blood salvage techniques is perioperative anemia. In the appropriate settings, using cell-saver and reinfusion drains may help decrease the risk associated with transfusion.
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General Surgical Technique

Minimize the size of the incision/minimally invasive surgery
One of the primary benefits of minimally invasive surgery is the significantly reduced risk of infection.\(^{26}\) Laparoscopic surgery, for example, is associated with fewer immune system reactions, lower incidence of complications, and better postoperative outcomes when compared with open surgery. Furthermore, the clinical consequences of a trocar site infection are much less significant than infection of a large laparotomy incision.\(^{27}\)

Use of endobags during laparoscopic procedures further serves to protect the wound from infection during specimen extraction.

Duration of the operation
The duration of an operation is defined as the time from skin incision to completion of skin closure. Duration is a measure of the extent of exposure to potential contamination.\(^{28}\)

Prolonged operative time may be related to the complexity of the surgery or to the surgical skills of the operative team. Longer operative duration is associated with higher infection rates.\(^{29}\) Duration of an operation has been associated with increased risk of SSI.\(^{22}\) Prolonged surgical duration is often related to increased blood loss, which can contribute to hypoxia. It also exposes the incision to desiccation and may increase the risk of microbial contamination and diminished efficacy of antimicrobial prophylaxis.\(^{28,30}\)

Wound irrigation
Wound irrigation removes debris, foreign material, and blood clots while decreasing the level of bacterial contamination.\(^{31}\) Normal saline or Lactated Ringer’s solution can be used for irrigation of clean wounds. The current literature does not support that antibiotic irrigation improves outcomes in patients treated with systemic antibiotics.\(^{32}\)

Drains
Drainage is used therapeutically as a component in the treatment of surgical abscesses when drainage reduces the size of the bacterial inoculum and provides a means of egress for the purulence. The role of drainage in preventing infection is unclear. Drainage may reduce the risk of seroma and hematoma formation by improving growth of tissue flaps. However, clinical studies have failed to show that drainage is effective as prophylaxis, and drainage is ineffective as prophylaxis against SSI after clean or clean-contaminated cases. The placement of drains through the surgical wound increases the incidence of SSI, presumably due to the inflammatory reaction caused by the foreign body.\(^{15,33-34}\) Drains are sites of bacterial adherence and biofilm formation, and may also function as an access site for the retrograde spread of infection to the patient. If drains must be used, a closed suction drain is
Intraoperative Issues (continued)

preferable to a passive open drain, such as a penrose drain. The wound should be drained through a site separate from the primary incision and the drain should be removed as early as possible, e.g., when there is nothing further to drain or when the drain is no longer functioning.²

Wound Closure

Primary wound closure facilitates the healing process and minimizes scar formation. Wound closure involves the use of sutures, staples, adhesive tape strips, cyanoacrylate, or tissue glue.

When using sutures, one must consider both suture material and suturing technique. Suture material may be evaluated according to its various characteristics: caliber, tensile strength, tissue reactivity, and permanence. Furthermore, sutures can be absorbable or non-absorbable; monofilamentous or braided; synthetic or natural. Sutures for wound closure are selected according to their specific function: closure of the fascia or other fibrous supporting structures; approximation of intermediate layers and obliteration of dead space; or skin closure. Furthermore, the suturing technique used is dictated by the specific tissue, as well as the location and type of wound being sutured. The minimum calibre of suture should be selected according to its function.¹⁹

The function of sutures is to approximate the divided tissues and to hold them immobilized relative to each other so that wound healing is facilitated. Closure of the wound is undertaken in layers with sutures placed principally in those layers that provide the greatest strength, e.g., dermis and fascia. Muscle, due to its expansile/contractile function, oriented as longitudinal fibers, holds sutures poorly. Therefore, its fascial covering is generally used for suturing and wound closure.

It is essential that sutures be tight enough to approximate the tissue, but not so tight as to cause tissue ischemia. Tissue ischemia can result from undue local tension that is worsened by subsequent swelling, which may occur some time after the completion of wound closure. During closure, the surgeon should be careful to obliterate dead space to avoid the formation of a seroma, but must do so discriminately. Suturing of subcutaneous tissues is associated with an increased infection rate induced by the devitalized tissue that is inherently produced by suture closure and the introduction of a foreign body—the suture itself—into the wound. Finally, the skin is closed with superficial placement of non-absorbable, monofilament suture or skin staples, the least inflammatory materials.³⁵ Alternatively, the surgeon may choose to close the skin with an absorbable subcuticular suture and adhesive tape strips or with a surgical tissue glue.

Suture removal takes place when the wound is strong enough to allow for their removal. The surgeon will consider the patient’s age, the surgical site, the type of wound, and the patient’s medications and comorbid conditions prior to suture removal. Sutures may need to stay in longer if the patient is malnourished; has diabetes or renal failure; or is being treated with steroids, immunosuppressants, or chemotherapy. Early suture removal can result in scar widening or disruption of the wound.
Intraoperative Issues (continued)

In otherwise healthy patients, an epithelialized tract will develop around sutures left in for more than 7 to 10 days. Face and neck wounds heal faster, presumably due to the excellent blood supply of the region, and sutures in face wounds may usually be removed after 4 to 5 days.35

The ability of the sutured tissue to resist infection varies depending on the suture material used. Certain types of suture material (silk and catgut) incite inflammatory responses and increase the potential of infection. Braided sutures have been shown to have a higher predisposition for microbial colonization compared with monofilamentous sutures, because bacteria may sequester within the braiding.36

Additionally, the use of antimicrobial-coated suture for abdominal wound closure is one technique that has recently been proven to decrease the risk of wound infections.37

Delayed primary wound closure
In the case of a wound infection or suspected wound infection, the surgeon may select to leave the wound open after completing the surgery. The wound will be covered with an occlusive dressing, and the patient will return to the operating room for wound closure once the contamination or infection is controlled.1

Secondary wound closure
When infection is suspected, the surgeon can also choose to let the wound heal secondarily. This may be the case with heavily contaminated wounds. It is also seen in wounds with significant tissue loss, or wounds in locations where the tissue will not tolerate the strain caused by approximation of wound edges.1

Glycemic Control
Elevated blood glucose levels in the postoperative period are associated with an increased risk for developing SSI. Therefore, it is crucial to control blood glucose levels in diabetic patients before they undergo surgical procedures and to avoid hyperglycemia during the procedures.17

Hyperglycemia during a procedure increases the likelihood of SSI for patients undergoing major cardiac surgery. Tight glucose control is an effective strategy to decrease the chance of postoperative infection.10

But glycemic control in the postoperative period for SSI prevention is recommended for cardiac surgery only. However, studies have demonstrated benefits for all such patients, whether diabetic or not.15,38

Perioperative hyperglycemia has been associated with increased SSIs, yet there is insufficient evidence to support strict glycemic control versus conventional management (blood glucose levels < 200 mg/dL).39
Infection Control and the Anesthesia Provider

SSIs, which are multifactorial, are related not only to individual patient risk factors and comorbidities, but also to the type of surgical procedure, the operating room environment, and the technical skills of the surgeon.

The anesthesia providers (anesthesiologist and nurse anesthetist) play a key role in the prevention of postoperative infections, including being responsible for the timely and appropriate administration of prophylactic antibiotic and maintenance of the patient's core normothermia.  

Limited research exists on the issue of transmission of pathogenic microorganisms in the anesthesia care setting. However, research has demonstrated that bacterial transfer to patients is associated with the variable aseptic practice of anesthesia personnel. The three main techniques that will help prevent infection transmission from the provider to the patient are aseptic technique (especially with management of multi-dose vials and use of needles with syringes), proper hand hygiene, and appropriate barrier techniques as recommended by the CDC.

Outbreaks of hepatitis B virus (HBV) and hepatitis C virus (HCV) outside the acute hospital setting indicate a growing problem of transmission of microorganisms by anesthesia personnel. The outbreaks, which were traced back to anesthesia providers, were caused by fundamental breaches in sterile technique and appropriate infection control practices.

The CDC recommends that single-dose vials should not be used for multiple patients, and that multi-dose vials should be assigned to a single patient whenever possible. The CDC guidelines also emphasize use of needles and syringes: a needle and syringe should be used only once; should never be reused on another patient; and should not be used to access a medication or solution once it has been used on a patient.

Refer to the CDC website and other websites for additional information:

http://www.cdc.gov/injectionsafety
(These guidelines identify aseptic technique, IV solutions, glucose monitoring, etc.)

http://www.oneandonlycampaign.org/Post/sections/43/Files/HIDA%20injection%20safety%20tool.pdf

http://www.oneandonlycampaign.org/Post/sections/8/Files/SIPCProviderBrochure.pdf


http://www.apic.org/Content/NavigationMenu/PracticeGuidance/PositionStatements/AJIC_Safe_Injection0310.pdf
Anesthesia providers generally have the lowest rate of adherence when it comes to hand hygiene. Hospital-based hand-hygiene efforts, which rarely target the operating room, are usually not focused on the anesthesia provider.\(^4^0\)

Anesthesia providers must adhere to the principles of sterile technique to prevent the spread of disease. This includes following the appropriate CDC guidelines, as well as those from medical and nursing professional associations, including the American Association of Nurse Anesthetists (AANA).\(^4^3\)


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**Key recommendations of these guidelines include the following:**

1. Handle blood, body fluids, and substances of all patients as if they were potentially infectious

2. Wash hands before and after all patient contact

3. Wear gloves when touching blood, body fluids, secretions, excretions, and contaminated items

4. Place used syringes and needles in a nearby puncture-resistant container without delay

5. In addition to Standard Precautions, use Contact Precautions for specified patients known or suspected to be infected or colonized with epidemiologically important microorganisms that can be transmitted by direct contact with the patient or by indirect contact via environmental surfaces

6. When administering medications, strict adherence to infection control procedures and Standard Precautions is required

7. Multiple-dose vials should be limited to a single-patient use unless strict aseptic technique is used and a new sterile syringe and access device are used each time the vial is penetrated

8. Due to the risk of cross-contamination, eye ointment, eyedrops, topical medications, etc., should be single-patient use
Intraoperative Issues (continued)

References


