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Infection and the Anesthesiologists and Intensivists

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A recent email advertisement for *Consumer Reports* stated that the frequency of nosocomial infections was "one in every 20 patients—and 90,000 of them die. Hospitals keep their infections secret from everyone, even though infection rates are on the rise. Healthcare workers wash their hands far less than they should, particularly in critical areas like intensive care, surgery, anesthesia and the emergency room." The advertisement went on to state that the magazine wanted 100,000 people to respond so that the magazine could advocate for changes in this area.

The public has become aware of the increasing rate of nosocomial infections, and this awareness will push hospitals and medical practitioners to document their infection rates and compliance with guidelines. Antibiotic resistance in United States intensive care units (ICUs) increases on a regular basis and has become a public health disaster. There are very few new antibiotic drugs being produced, and the cost and morbidity of infections caused by these resistant organisms is significant. This review will go over infections that are related to anesthesia practice, including vascular catheter-related infections, endotracheal tube-related infections, regional anesthesia-related infections, and antibiotic prophylaxis for surgical patients. These are the issues that several groups are highlighting for national monitoring.

Vascular Catheters and Infection

The number of estimated deaths from vascular catheter infections is 500–4000 annually (1,2). Pittet and Wenzel (3) reported that catheter infection carries an odds ratio for death as high as 20.45 (95% confidence interval, 18.9–22.1). Therefore, vascular catheter-related infections clearly are frequent and lethal.

It is not clear that placing a vascular catheter at a specific site increases the risk of infection. Merrer et al. (2) showed an increase in infections in catheters placed in the femoral vein in a randomized, multicenter investigation. However, junior physicians placed the catheters, and minor and major infections were assessed. Other investigations have *not* found that femoral venous catheters become infected more often (4). Most recently, a prospective investigation of the colonization and infection rate of subclavian, internal jugular, and femoral vein catheters was performed at a single institution (4). The investigation included surveillance of 831 venous catheters and 4735 catheter days in 657 critically ill patients. The incidence of overall venous catheter infection was 2.3% or 4.01/1000 catheter days and the colonization rate was 2.9% of the catheters or 5.07/1000 catheter days (4). The incidence of infections of patients with one catheter in the femoral vein was 1.4% or 2.9/1000 catheter days. In comparison, patients with one subclavian venous catheter had an infection rate of 0.9/1000 days or 0.5%. Patients with one internal jugular venous catheter had an infection rate of 0/1000 days or 0%. These rates were not statistically different.

When patients had catheters in more than one site, there also was no statistical difference in the rates of infection or colonization (4).

This epidemiologic investigation performed at one center suggests that all three venous insertion sites have the same risk of catheter infection when catheter insertion is performed by senior operators, strict sterile insertion technique is utilized, and standardized continuous catheter care is done by trained ICU nurses (4). Notably the protocol for insertion demands the use of 2% iodine tincture to clean the skin at the insertion site and that operators wear sterile surgical gowns, gloves, and masks and utilize a large drape. Iodine ointment was placed at the insertion site and transparent dressing was used to maximally visualize the insertion site. Evaluation of line infection was based on the semiquantitative technique of Maki et al. (5).

Conclusions

Anesthesiologists placing central lines in the operating room will be held to the same standard as intensivists. Therefore, anesthesiologists need to use the same protocols that ICU physicians use to maximize the sterility of venous lines. Those protocols uniformly demand the use of sterile gowns, gloves, masks, and large drapes during insertion (6). All three venous sites, internal jugular, subclavian, and femoral, appear similar in terms of rate of infections (4). Antibiotic-coated hemodialysis catheters decrease the rate of infections in patients with acute renal failure (7). The use of antibiotic-coated venous catheters has been shown to be efficacious; experts have recommended the use of chlorhexidine/silver sulfadiazine catheter in high-risk patients requiring catheterization for up to 10 days (1).

Endotracheal Tube Related Infections

It has become a national priority to reduce the incidence of surgical complications over the next 5 years (Surgical Care Improvement Project, SCIP, the OK Foundation for Medical Quality). Pulmonary complications are more frequent than cardiac complications after nonthoracic surgery and are associated with greater increases in length of stay in the hospital. Perioperative pneumonia is associated with a mortality of 21% to 46% compared with a 2% mortality in similar patients who did not develop pneumonia (8,9). Risk factors for the development of perioperative pneumonia include the risks from surgery and from the patient's preoperative health problems (8). Any surgery associated with prolonged endotracheal intubation increases the risk for the development of pneumonia; this includes neurosurgery, surgery on the neck, and surgery involving the thorax or upper abdomen (8). The rate for development of perioperative pneumonia increases if a patient undergoes a high-risk surgery and has other risk factors, such as advanced age, chronic obstructive lung disease, renal insufficiency and a poor functional status. Patients with this combination of risk factors had a 16% incidence of developing perioperative pneumonia compared with 1.5% in patients without these risk factors (8).

Nosocomial pneumonia is the leading cause of death from hospital-acquired infections (9). Nearly one third of ventilated patients are at risk for the development of a subset of nosocomial pneumonia called ventilator-associated pneumonia (VAP), a lung infection in a patient who has been ventilated for 48 h or more. The mortality of VAP is between 17% and 50% and is associated with prolonged mechanical ventilation and increased hospital cost (10). When mechanical ventilation is required for prolonged intervals, the risk of developing VAP increases to nearly 100% (10). Empiric antibiotic therapy of suspected VAP increases the duration and quantity of antibiotic administration and does not insure improved outcomes, as the therapy often proves to be inadequate as a result of antibiotic resistance of the cultured bacteria (11).

It is widely believed that the trachea and endotracheal tube are sterile in patients who have normal lungs when they are first intubated and that bacterial colonization occurs progressively, which then frequently leads to nosocomial pneumonia. It has been suggested that VAP, a subset of nosocomial pneumonia, is seen after oropharyngeal colonization, which occurs rapidly in ICU patients (12–14). Multiple factors cause the oropharyngeal colonization, including desiccation of the mucosa, decreased salivary secretion, mechanical injury induced by nasogastric and endotracheal tubes and decreased immunoglobulin-A content (14). Dental plaque also appears to be a source of nosocomial colonization and infections in ICU patients. Dental plaque exists on the subgingival and supragingival surfaces of the teeth. Sequential sampling of dental plaque from ICU patients has shown that usually greater than 50% of patients acquiring a respiratory infection are previously colonized at dentogingival sites by the same pathogens (14). In fact, El-Sohl (14) documented that the respiratory pathogens isolated from dental plaque genetically matched those recovered from bronchoalveolar lavage in patients from nursing homes. Therefore, many patients are not newly colonized in the hospital, but rather the bacteria found in their lungs are coming from their oral flora and from dental plaque.

There have now been at least 12 small clinical studies (12–15) that attempted to prevent perioperative pneumonia by manipulating oral flora. Most of the investigations used prophylactic chlorhexidine oral rinse preoperatively and perioperatively to significantly decrease nosocomial pneumonia. DeRiso et al. (13) documented a significantly decreased incidence of nosocomial lung infections in patients undergoing open-heart surgeries who received the antiseptic rinse as part of a double-blind placebo-controlled trial of twice-daily 0.12% chlorhexidine oral rinse. Systemic antibiotic use and mortality were also significantly decreased in the patients who received the antiseptic oral rinse. The patients who received the chlorhexidine had a 5% rate of infection compared with the non-treated patients, who had a 14% rate of nosocomial respiratory infection. The patients who received the chlorhexidine had a 1.2% mortality and the untreated patients had a 5.6% mortality In another trial that was *not* double-blind, a 52% reduction in the prevalence of nosocomial pneumonia occurred with chlorhexidine rinses in patients undergoing heart surgery (15,16). Therefore, antiseptic rinsing has been successful in decreasing nosocomial infections in cardiac surgical patients.

Conclusions

Lung infections occur in patients who have prolonged endotracheal intubations. The oral flora and dental plaque appear to be a significant, if not the major, source of bacteria in nosocomial lung infections.

Therefore, preoperative and perioperative oral examinations are being evaluated for their utility in preventing perioperative lung infections. Patients with very poor dentition may be at higher risk for perioperative lung infections.

Regional Procedures and Infections

Risk factors and conditions suspected of contributing to infections of regional procedures include diabetes, drug abuse and alcoholism, sepsis, immunosuppressive treatments, site of catheter insertion, technically difficult catheter insertion, hematoma formation near catheter insertion, duration of catheter use and disconnecting the system utilized for local anesthesia delivery (16). Recently a prospective investigation of patients receiving peripheral or epidural catheters in Germany documented the low rate of infection with regional anesthesia (16). However several important facts regarding the investigation need to be noted. First, the procedure for catheter placement was standardized. All anesthesiologists wore a hood, face mask, sterile gloves after hand disinfection, and a sterile coat; and a large sterile drape was always utilized (16).

The skin was disinfected for 1 min using a disinfectant. Bacterial filters and a transparent dressing were used for every procedure. Nearly all patients also received a single shot of perioperative antibiotic prophylaxis (16). Finally, catheters were removed after skin disinfectant was applied. All catheter tips were cultured.

One hundred and ninety-eight catheters from 189 patients were evaluated. Catheters were placed primarily in the epidural space, in a paravertebral location, in the psoas compartment, near the femoral nerve, in the interscalene plexus, in the infraclavicular plexus, and in the axillary plexus. Forty-seven (24%) of the catheters were not sterile. However, the quantity of bacteria cultured from 14 catheter tips was "insignificant." The cultures from the tips of 33/198 (17%) had a critical burden, or greater than or equal to 15 colony-forming units of bacteria were found, and these catheters were called colonized. Eighteen of the 33 had signs of local inflammation (16).

The only factors that were found by stepwise logistic regression to predict the development of colonization included catheter placement in the groin; removing the transparent dressing also increased the risk slightly. Postoperative administration of an antibiotic drug for 24 h was found to decrease the risk of infection (16).

In this investigation only two patients (1%) had signs of clinical infection, meaning they had fever, increased white cell count, and signs of local inflammation. Both infections were with *Staphylococcus* (16). Other investigations have also reported rates of abscesses of 1%–3% (16).

Conclusions

This recent investigation suggests clinical infections of catheters utilized for regional anesthesia are very rare (16). Practitioners should be aware that strict protocols for sterile placement are being utilized by many groups, so that if the local rate of infection is higher than those published, lack of adherence to published protocols could be a problem.

Antibiotic Prophylaxis for Surgeries

The prophylactic use of antibiotics is effective in preventing postoperative wound infections in a range of surgical procedures (17–20). Surgical site infections (SSIs) are the second most common cause of nosocomial infections (17). Up to 2%–5% of patients undergoing clean extra-abdominal operations and up to 20% of patients undergoing intra-abdominal operations will develop a SSI (17). Patients who develop SSIs are up to 60% more likely to spend time in an ICU and have twice the mortality of patients without SSIs (17). The National Surgical Infection Prevention Project or SIP (http://www.medqic.org/sip) was implemented in 2002 by the Centers for Medicare and Medicaid Services (CMS) and the CDC. The surgeries to be monitored were chosen because there were no disagreements regarding the antibiotics to be administered prophylactically (Figure 1). The surgeries include coronary artery bypass grafting and other open-chest cardiac surgery, vascular surgeries including aneurysm repairs, thromboendarterectomies and vein bypasses, general abdominal colorectal surgeries, hip and knee arthroplasties, and abdominal and vaginal hysterectomies. The panel of experts in this program have developed three performance measures to compare hospitals:

A) The proportion of patients who receive parenteral antimicrobial prophylaxis within 1 h of an incision.

B) The proportion of patients who are given an antimicrobial agent that is consistent with current guidelines

C) The proportion of patients whose prophylactic antimicrobial agent is discontinued within 24 h after the end of the surgery.

The SIP project and guidelines have been reviewed in the *American Journal of Surgery* (17). Antibiotics are to be given 1 h before incision so that serum levels are adequate during the operation (17). Fluoroquinolones or vancomycin should be administered 2 h before the incision so that infusions can be given slowly (17). Prophylactic antibiotics should not be given after 24 h

Surgical Infection Prevention Antibiotic Recommendations

Surgical Procedure	Approved Antibiotics
Cardiac or Vascular	Cefazolin (Ancef) **or** Cefuroxime (Zinacef) **or** Cefamandole (Mandol) **or** Vancomycin* (Vancocin) **or** Clindamycin* (Cleocin)
Hip/Knee Arthroplasty	Cefazolin (Ancef) **or** Cefuroxime (Zinacef) **or** Vancomycin* (Vancocin) **or** Clindamycin* (Cleocin)
Colon	Oral: after effective mechanical bowel preparation, Neomycin sulfate + Erythromycin base **or** Neomycin sulfate + Metronidazole Administered for 18 hours preoperatively. Parenteral: Cefoxitin (Mefoxin) **or** Cefotetan (Cefotan) **or** Cefmetazole (Zefazone) **or** Cefazolin (Ancef) + Metronidazole (Flagyl) *See special considerations for β-lactam allergy
Hysterectomy	Cefazolin (Ancef) **or** Cefotetan (Cefotan) **or** Cefoxitin (Mefoxin) **or** Cefuroxime (Zinacef) *See special considerations for β-lactam allergy
*Special Considerations for β-lactam allergy patients	• For cardiac, orthopedic, and vascular surgery, if the patient is allergic to β-lactam antibiotics, vancomycin or clindamycin are acceptable substitutes. • For hysterectomy and colon surgery, no guideline recommendations for parenteral antimicrobial prophylaxis have been published for patients with β-lactam allergy.

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Figure 1. Surgical infection prevention antibiotic recommendations.

after the operation; the only exception is for cardiothoracic surgery, where prophylaxis has been recommended by some groups for 72 h (17). There is no consensus regarding the use of vancomycin for prophylaxis in hospitals where there are "high" levels of methicillin-resistant *Staphylococcus aureus* (21). In fact, investigations have not been able to show that using vancomycin as the prophylactic antibiotic decreases SSI rates when compared with the use of cephazolin (21). Nonetheless, for patients with known methicillin-resistant *Staphylococcus aureus* colonization, vancomycin should be considered the appropriate antimicrobial agent for prophylaxis (17).

In a report from France using an extensive perioperative database that had been established to investigate perioperative antibiotic prophylaxis, 2374 patients underwent abdominal surgery but not colorectal surgery. Antibiotic prophylaxis was administered to 1943 patients. The patients who received antibiotic prophylaxis and those that did not were roughly equal and the rates of SSI were 2.4% versus 4.2% (20). Therefore, prophylactic antibiotics did decrease the rate of SSI significantly. The administration of prophylactic antibiotics did not decrease global infectious complications, deep infections, urinary infections, or vascular catheter infections (20). Furthermore, this report documented that patients at high risk for SSI (i.e., patients with cirrhosis) also had a significant decrease in SSI although their rate of SSIs was higher than patients at lower risk (20).

One of the major barriers to achieving fewer infections has been physician behavior. To improve compliance with guidelines, schemes have included insurance repayment only for appropriate antibiotic administration (18). Therefore, if the patient received antibiotics that were not listed on the guidelines for prophylaxis, the insurance company would not pay. To administer an antibiotic that was not listed on the guidelines, the physician had to register an exception with the hospital. Clinical pharmacists sent physicians notes regarding which antibiotics to use and the cost of using non-guideline antibiotics (18).

Conclusions

Hospitals will want to publish that their rates of SSI meet the norm or are better. Anesthesiologists have a major responsibility for compliance and achieving good marks on the performance measures of the SIP project.

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