CURRENT PROPHYLACTIC PERIOPERATIVE ANTIBIOTIC GUIDELINES IN TRAUMA: A REVIEW OF THE LITERATURE AND OUTCOME DATA

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Abstract

A comprehensive review of prophylactic use of perioperative antibiotics in trauma from the 1970s to the present was performed. Evidence based guidelines were used to analyze the data from the past 32 years and define standards of care in the field. Recommendations and suggestions are provided to offer guidelines for prophylactic antibiotic use in trauma. Highlighted topics include general trauma surgery, with focus placed on abdominal and thoracic surgery in trauma, and non-trauma surgery, including subspecialties, for comparison.

KEY WORDS: guidelines. prophylactic antibiotic use in trauma, data from the past 32 years, define standards of care.

Introduction

Management of surgical site infections has remained an important topic over the years, and use of prophylactic perioperative antibiotics continues to ignite controversy. While there is no doubt that antisepsis has changed the face of surgery, there exists a wide spectrum of beliefs on duration and use of perioperative antibiotics. Practices based on limited experience have been replaced with scientific evidence of the benefits and perils of antibiotics. Despite the decreased morbidity and mortality ascribed to antisepsis, there are complications associated with overuse. The history of this topic dates back more than thirty years and the need for guidelines for antibiotic use is more necessary today than ever before. This review highlights the historical aspects of antisepsis in surgery and focuses on the current use in general trauma, including abdominal and thoracic surgery, as well as in non-traumatic general and subspecialty surgery.

The studies cited in support of the current recommendations have been selected using a Medline search since 1977. The historical background provided comes from a wide variety of sources in the surgical literature. Most citations supporting the current recommendations are prospective, randomized studies with retrospective data used in cases where prospective data is unavailable.

Historical Background

As an English surgeon promoting the idea of sterile surgery in the 1860s, Joseph Lister used phenols to sterilize surgical instruments and clean wounds. Expanding on Louis Pasteur's concepts of eradicating micro-organisms in wounds, Lister introduced antisepsis to surgery and made surgeons wash their hands and wear clean gloves, a novel concept at the time. Before his principles were accepted into use, surgery commonly resulted in post-operative fevers and infection, which often lead to sepsis and death. Lister was surrounded by contemporaries that echoed his sentiments of antisepsis. Ignaz Semmelweis, a Hungarian physician in the 1800s, discovered that puerperal fever could be decreased if physicians washed their hands in a chlorinated lime solution. He had many followers such as American born Oliver Wendell Holmes Sr, who advocated for medical reform in Cambridge, Massachusetts. Semmelweis' ideas, however, did not gain wide acceptance until after his death, when Louis Pasteur developed the germ theory of disease in the late 1860s, thus providing a theoretical explanation for the initiative. Florence Nightingale, a British nurse who brought these similar pioneering principles to the Crimean War in the 1850s, revolutionized the perception of infection by introducing the concept that cleanliness and sterility were barriers to infectious disease. Since the introduction of antiseptic technique, surgery has continued to evolve into a process that cures disease and prolongs life (1). US Surgery data states that there were approximately 28.5 million surgical procedures performed in 2004. This number is estimated to reach more than 38 million by 2012 (2). From the most recent available data from the National Nosocomial Infections Surveillance (NNIS), there were 274,100 surgical site infections (SSI) in the US in 2002, roughly 2 infections per 100 procedures (3). Surgical site infections cause significant morbidity for patients and are costly for hospitals, thus making prevention an important topic. Various methods of decreasing SSI include recommendations for preoperative, intraoperative, and postoperative practices. Preoperative techniques include proper scrubbing of hands prior to surgery and appropriate patient selection as well as patient preparation prior to surgery. Intraoperative techniques include proper sterile procedure with avoidance of unnecessary tissue destruction along with optimizing the operating room environment to decrease the chance of infection by monitoring patient aspects such as temperature and the sterile environment. Postoperative patient care is important to maintain the integrity of the surgical wound. The use of perioperative antibiotics should only be seen as an adjunct to careful technique and proper procedure. Perioperative antibiotics are thought to decrease surgical site infections and, as such, have become an important topic of discussion for the surgeon. The use of prophylactic antibiotics in general surgery is well established and the evidence supporting this practice is overwhelming. Trauma surgery, however, has not been studied as extensively with regard to antibiotic usage. Surgery for traumatic wounds presents a unique perspective as the patients are often mechanically contaminated by foreign debris in the wound. Yet another detractor is the multi-service approach to caring for the trauma victim resulting in input from a variety of specialties, most of which have differing viewpoints on antibiotic prophylaxis and duration of therapy. More and more literature has emerged in an attempt to provide guidelines for prophylactic antibiotic use in trauma patients undergoing surgery.

The Perils of Antibiotic Overuse

Although perioperative antibiotic use has gained wide acceptance as a measure to decrease surgical site infections in general surgery and has become a mainstay of our daily practice, it is not without risk. The overuse and misuse of antibiotics has been linked to organism resistance that leaves physicians with limited tools to use against these bacteria. Complications such as ventilator associated pneumonia (VAP), candidal infections, catheter-associated infections such as urinary tract infections and central line infections, and clostridium difficile colitis have been linked with antibiotic overuse as well (4). There has been increased interest in prevention protocols for these complications such as interventions studied to decrease catheter related infections in the intensive care unit (5). Hoth looked at the effect that prolonged antibiotics (greater than 48h) had on trauma patients and the formation of VAP. Patients who received prolonged prophylactic antibiotics before the diagnosis of VAP had the pneumonia diagnosed later than usual, by an organism that was more resistant, with an incidence

of antibiotic complications twice that of patients who did not receive prolonged prophylactic antibiotics. The prophylactic prolonged antibiotics shifted the pattern from early to late-onset nosocomial VAP with different organisms, which are more virulent and harder to eradicate, therefore increasing the morbidity and mortality caused by VAP in these patients. In this study, the primary reasons for greater than 48 hours of antibiotics perioperatively were open fractures and external ventricular drains. However, often prophylaxis is not stopped appropriately due to oversight of physicians, residents, or the logistics of the computerized ordering systems, therefore contributing to the cost and complications associated with antibiotic usage (6). Lansford looked at the efficacy of a pneumonia prevention protocol in the reduction of VAP in trauma patients. Their VAP protocol included keeping the head of the bed > 30 degrees, twice a day chlorhexidine oral swabs, daily vent weaning by respiratory therapists, and trading nasogastric tubes for orogastric tubes when able. The conclusion was that VAP protocols may decrease VAP incidence in trauma patients. Pneumonia is the second most common nosocomial infection in the intensive care unit and the CDC has documented that trauma patients have among the highest incidence of VAP with 15.1 cases/1000 vent days, thus making prevention of VAPs both cost-effective for the hospital and beneficial for our trauma patient population (7). At our institution, we adopted the current Institute for Healthcare Improvement (IHI) guidelines for the creation of a VAP bundle protocol in our trauma intensive care unit. The recommended bundle consists of five elements: maintaining the patient's head of the bed above 30-45 degrees, daily sedation breaks, daily assessment for extubation, peptic ulcer prophylaxis, and deep venous thrombosis prophylaxis (4). Implementation of this bundle (See Table 1) for a period of eighteen months allowed us to decrease our VAP rate by 231% (unpublished data). Many studies have shown that alterations in antibiotic choice are associated with a decrease in antibiotic resistance patterns. Raymond performed an outcome analysis in which they showed a statistically significant reduction in the incidence of antibiotic resistant gram-positive infections, antibiotic resistant gram-negative rod infections, and mortality associated with infection during quarterly rotation of empiric antibiotic schedules. Their patient population included intensive care units (ICUs) consisting of general, transplant or trauma surgery patients who developed pneumonia, peritonitis, or sepsis of unknown origin. They further showed that age, Apache II scores, solid organ transplant, and

malignancy were independent predictors of mortality and that antibiotic rotation was an independent predictor of survival in this patient population (8).

1. Head of bed above 30-45 degrees
2. Daily sedation breaks
3. Daily assessment for extubation
4. Peptic ulcer prophylaxis
5. Deep venous thrombosis prophylaxis

TABLE 1. Institute for Healthcare Improvement Guidelines for VAP Bundle Protocol
Adopted from www.IHI.org

Most institutions implement departmental guidelines on antibiotic usage based on evidence based medicine. It is interesting, however, that much variety exists from one center to another when it comes to prophylactic antibiotic usage prior to surgical procedures. At our level one academic trauma center, the trauma surgery department has been working closely with several subspecialty surgical departments to implement protocols to limit the duration of prophylactic perioperative antibiotics and to establish a perioperative time frame that terminates usage, at most, 24 hours after surgery. We recently collaborated with the oral-maxillofacial surgery department to prospectively examine our experience of antibiotic use in the setting of facial fractures to determine whether the application of a 24 hour protocol of peri-operative antibiotics affects the rate of osteomyelitis or superficial wound infection. Our conclusion was that treating patients with exclusively peri-operative antibiotics in facial fractures repaired within 72 hours has shown no increase in infection rates at our institution. Standardizing antibiotic usage with our protocol has increased the number of patients that receive only prophylactic antibiotics, potentially decreasing health care costs and decreasing complications associated with antibiotic resistance (unpublished data presented at the American Association for the Surgery of Trauma-AAST in 2008 with manuscript in preparation). It remains our goal to perform similar prospective studies with our neurosurgical, otolaryngology, and orthopaedic departments so that we may standardize our perioperative prophylactic antibiotic use as an institution. This is regarded as a highly important matter as these departments work closely to care for the trauma patient. Thus it would be prudent and cost-effective for an institution to have a uniform system of guidelines in place that is followed by all of the integral services that provide surgical care to that trauma patient. Our goal is to standardize antibiotic use while allowing for occasional exceptions, as clinically indicated.

Literature Review for Prophylactic Antibiotics in General Trauma Surgery

Trauma is the leading cause of death between the ages of 1 and 37 and is the fourth leading cause of death in the United States. It is well known that infection plays a large role in the morbidity and mortality of trauma patients. Injured patients represent a unique population of surgical patients that are more prone to infection. Some predisposing factors include an amplified host defense mechanism and activation of the complement cascade that characterizes tissue damage in severe injury. Similarly, decreased tissue perfusion is an important predisposing factor to infections. Unique to trauma is the extrinsic factor of mechanical contamination of the wound with foreign material. Prior to evaluating the literature, it would be beneficial to review the classification of surgical wounds. Guidelines from the Centers of Disease Control and Prevention and the stratification of surgical wounds are as follows: A Class I (clean) wound is one in which the respiratory, alimentary, genital, and urinary tracts are not entered as part of the surgical procedure. Conditions under which a patient undergoing a Class I, clean, procedure should receive prophylactic antibiotics include those in which prosthetic material is used or the procedure enters a joint such as a total hip arthroplasty. Class II (clean-contaminated) wounds are ones in which the respiratory, alimentary, genital, or urinary tracts are entered under controlled conditions. Class III (contaminated) wounds are those that are open wounds or incisions made as part of the operation where major breaks in sterile technique or gross spillage of gastrointestinal contents has occurred. Class IV (dirty) wounds are those that include old traumatic wounds or involve existing clinical infection or perforated viscera. Patients undergoing Class IV, dirty operations should not receive prophylactic antibiotics; rather they should receive therapeutic antibiotics directed at anticipated organisms based on anatomic location and mechanism of injury. It is held in common agreement that patients undergoing procedures that involve entry into a hollow viscous under controlled conditions should undergo antibacterial prophylaxis (9, 10). see Table 2.

Alexander examined clinical trials of prophylactic antibiotics in trauma and found that in abdominal trauma, preoperative antibiotics decrease the infection rate when compared to intraoperative or postoperative administration of antibiotics. Duration of these prophylactic antibiotics is not well established in trauma. Antibiotics were not favored in burn trauma or superficial lacerations; prophylactic antibiotics in fractures were found to decrease infection rates, yet there was no consensus on duration. There was no evidence that greater than 48 hours of antibiotics has any benefit in trauma. On the contrary, they may be harmful. Noting that continued contamination is the primary reason for antibiotic ineffectiveness, when choosing prophylactic antibiotics in trauma, more rapidly penetrating ones such as ampicillin, penicillin, cephalosporins or tetracycline are good options (11). Thus antibiotics should only be used as an adjunct to aggressive irrigation and debridement of contaminated wounds. Cushing echoes this sentiment of immunosuppression of the injured patient and claims that not much has changed in terms of prophylactic antibiotic usage since 1977. In penetrating trauma to the chest, infection depends on the severity and contamination of the wound as well as the condition of the patient. Penetrating trauma to the abdomen is often associated with bowel perforation which is in turn associated with infections of mixed bowel flora. Preoperative antibiotics in this scenario decrease the incidence and severity of wound and deep tissue infections. However, proper surgical aseptic technique is the best way to ward off infection and constantly being aware of the organism that you are treating is the

Class I	Clean	An uninfected operative wound in which no inflammation is encountered and the respiratory, alimentary, genital, or uninfected urinary tracts are not entered. In addition, clean wounds are primarily closed and, if necessary, drained with closed drainage. Operative incisional wounds that follow nonpenetrating (blunt) trauma should be included in this category if they meet the criteria.
Class II	Clean-Contaminated	Operative wounds in which the respiratory, alimentary, genital, or urinary tracts are entered under controlled conditions and without unusual contamination. Specifically, operations involving the biliary tract, appendix, vagina, and oropharynx are included in this category, provided no evidence of infection or major break in technique is encountered.
Class III	Contaminated	Open, fresh, accidental wounds. In addition, operations with major breaks in sterile technique (e.g., open cardiac massage) or gross spillage from the gastrointestinal tract, and incisions in which acute, nonpurulent inflammation is encountered are included in this category.
Class IV	Dirty	Includes old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the organisms causing postoperative infection were present in the operative field before the operation.

TABLE 2. Classification of Surgical Wounds

best way to properly use preoperative antibiotics (12). Sawyer reviewed a large number of consecutive surgical infections in order to identify the demographics and characteristics of infections in surgical patients to clarify the areas that needed emphasis. The most common sites of infection were the colon, lung, and the surgical wound; staphylococcus epidermidis, staphylococcus aureus, and candida albicans were the most common organisms isolated. The most frequently used antibiotics were ciprofloxacin, vancomycin and metronidazole. Overall the death rate was 13%, ranging from 5% of community-acquired infection to 25% of nosocomial infections in the ICU. His conclusions were that surgeons deal mainly with nosocomial infections resulting in increased morbidity and mortality so an emphasis should be placed on preventing infections acquired in the hospital (13). Velmahos compared prophylactic antibiotic duration after severe trauma and showed that there was no difference in using one antibiotic for 24 hours when compared to multiple antibiotics for longer than 24 hours, thus concluding that a single agent for 24 hours of prophylaxis is effective. The surgical infection society (SIS) recommends a short duration of prophylactic (less than 24 hours) antibiotics with a spectrum appropriate to the operative site. Good data is available supporting short-term single agent antibiotic prophylaxis in low-risk patients, but has been indeterminate in high-risk patients so this study was designed to evaluate high-risk trauma patients (14). The SIS recommendations for low-risk patients seem to apply for high-risk as well.

Literature Focus on Abdominal Surgery in Trauma

Abdominal trauma is a particularly important focus as it comprises a large portion of commonly found injuries. Contamination is frequently present, so antibiotic prophylaxis is truly a euphemism for therapeutic treatment. Ericsson looked at the hazards of underdosing prophylactic antibiotics in abdominal trauma surgery. There was no difference between infection rates in 72 hours of coverage with prophylactic amikacin and clindamycin versus 24 hours of coverage in trauma laparotomy patients. They recommended that higher initial doses were more effective than long courses in laparotomy patients. The patient population included high-risk trauma patients, thus suggesting that prophylactic antibiotics are useful in patients at high risk for infection, such as increased estimated blood loss or spillage of colonic contents. They recommend covering aerobic and anaerobic organisms and also saw no difference seen in the

interval at which the antibiotics were given, q6 hours or q12 hours (15). They further tested their theory that antibiotic pharmacokinetic profiles were altered in trauma patients and that this was related to resuscitative fluid administration therefore accounting for the increase in antibiotic requirements. They show that the volume of distribution is increased in all of their included trauma patients secondary to increased fluid resuscitation therefore diluting the administered drug. They maintain their original recommendation of using a higher initial dose of prophylactic antibiotics, instead of a prolonged course, in patients with abdominal trauma (16). Fabian looked at prophylactic antibiotic use in penetrating abdominal trauma and concluded that antibiotics should be discontinued after the operation is over in penetrating abdominal trauma. In this series, shotgun wounds carried the greatest risk for postoperative infection, followed by rectal injuries and colon injuries and cefotaxime was considered a drug with adequate properties for such prophylaxis (17). Hofstetter compared a triple drug regimen of an aminoglycoside, ampicillin, and clindamycin to cefoxitin alone for 24 hour prophylaxis in laparotomy for trauma in 119 patients. Excluding remote site infections, the abdominal wound and intraperitoneal infection rate was 13.0% for the cefoxitin group and 12.0% for the triple-drug group. He concluded that a 24 hour course of cefoxitin, a second-generation cephalosporin, was a safe prophylactic regimen in abdominal trauma (18). Sarmiento also found no difference in infections among low-risk patients with abdominal trauma given prophylactic intraoperative antibiotics, which were suspended at the end of surgery, when compared to those given prophylactic intraoperative antibiotics that were prolonged until 48 hours. Low-risk patients were identified as ones with an abdominal trauma index (ATI) less than 25. They reasoned that for patients with an ATI greater than 25, such as colonic wounds, antibiotics should be continued for 48 hours as a colonic wound was one of the strongest indicators for postoperative administration of antibiotics. However, for low-risk wounds with an ATI less than 25, 24 hours of perioperative antibiotics was sufficient for prophylaxis (19). Weigelt compared penetrating abdominal trauma patients who were given a prophylactic regimen of ampicillin/sulbactam to those given cefoxitin. There was an increased incidence of enterococcal infection in the cefoxitin group resulting in the conclusion that a single, broad-spectrum antibiotic for prophylaxis (including improved enteroccocal and bacteroides coverage) for 24 hours perioperatively effectively controls surgical

wound infections. Their findings join others in suggesting that a perioperative antibiotic for abdominal trauma should include anaerobic and aerobic coverage (20). Maxwell and Fabian offer a comprehensive review of colon trauma from World War I to 2003. They recommend that prophylactic antibiotics are appropriate for most types of gastrointestinal surgery associated with trauma. They support the use of the least expensive, most commonly available agent such as a second-generation cephalosporin and advocate use that defines 12 to 24 hours of antibiotic coverage instead of more lengthy courses of therapy (21). The conclusion of these multiple studies is that in penetrating abdominal trauma, 24 hours of a second-generation cephalosporin is adequate perioperative antibiotic prophylaxis with some surgeons preferring to add enterococcal and bacteroides coverage to this regimen.

Literature Focus on Thoracic Surgery in Trauma

Eren looked at the risk factors and management of traumatic empyema and noted that posttraumatic empyema increases morbidity and mortality, length of stay, and cost. In this series, duration of chest tubes over six days, length of stay in the ICU greater than 2 days, lung contusion, retained hemothorax, and an exploratory laparotomy are shown to be independent predictors of posttraumatic empyema and the use of prophylactic antibiotics is recommended for those patients. The relative risk of posttraumatic empyema is increased if the injury is from penetrating trauma, the patient has associated injuries, or there is fracture of more than two ribs. Other than these scenarios, the criteria for antibiotic prophylaxis are emergent/urgent thoracotomy, soft-tissue destruction of the chest wall by shot-gun injury, and associated open long bone fracture (22). Holzheimer commented on a meta-analysis done on randomized controlled trials on prophylactic antibiotics in chest trauma that showed inconsistent data and maintains that the ultimate decision is up to the surgeon, and that one should look at the patient's risk factors, mechanism of trauma, extent of trauma, and transfusion requirements before deciding on prophylactic antibiotics (23). Mandal compared prophylactic antibiotics to no antibiotics in penetrating chest trauma and found no difference in outcome, concluding that routine antibiotic prophylaxis is not recommended in penetrating chest trauma. Unless there is an esophageal tear, the risk of microbial contamination of the mediastinum and pleural cavity is negligible because of the sterile

nature of the tracheobronchial tree (24). They also examined the 24-year experience at their trauma center with posttraumatic empyema and found that of 5,474 patients, 1.6% developed empyema after no use of prophylactic chest tube antibiotics. They found that of those empyemas, 91% were cured with chest tube placement and did not require thoracotomy, so they concluded that no routine use of antibiotic prophylaxis is necessary for all trauma patients with chest tubes (25). It is prudent, however, to mention that the Eastern Association for the Surgery of Trauma (EAST) practice guidelines for prophylactic antibiotic use in tube thoracostomy for traumatic hemopneumothorax presents level III recommendations, of Class I and II data, that a first-generation cephalosporin should be used for no longer than 24 hours. They suggest that there may be a reduction in pneumonia, but not empyema, in trauma patients receiving prophylactic antibiotics when a tube thoracostomy is placed (26).

Literature on Non-Trauma and Subspecialty Surgery Antibiotic Protocols for Prophylaxis

A plethora of literature exists in non-trauma surgery favoring prophylactic perioperative antibiotic usage to reduce postoperative infection. This has been well established in general surgery, general non-trauma thoracic surgery, and subspecialty otolaryngology (ENT) surgery. For example, pre-operative bowel preparations, body temperature control, and perioperative antibiotic use has had a great impact on decreasing infections after abdominal surgery. The principle of decreasing surgical site infection applies in non-trauma surgery and results in increased hospital stay, morbidity and mortality. This, once again, highlights the importance of prevention. Allen echoes the sentiments of many others in stating that meticulous technique and proper procedure is the number one way to decrease surgical site infections, and that perioperative antibiotics should only be viewed as an adjunct to careful surgical procedure. He focused on pneumonia and empyema following general thoracic surgery and, after reviewing 14 studies in the thoracic literature, concluded that prophylactic antibiotics decrease wound infection and that a short course is more effective than a longer course (1). The otolaryngology surgical literature provides convincing evidence that perioperative antibiotics decrease wound infections in head and neck surgery patients. As in most surgeries, wound contamination is the biggest reason for post-operative infection and in the ENT literature, aerobes are most commonly found in surgi-

cal wound specimens. Clayman obtained specimens of pus or draining fluids from the wounds of 43 surgical patients who received perioperative antibiotics, and then analyzed the bacteriologic profile of these surgical infections after antibiotic prophylaxis. He found polymicrobial infection in 30%, with 82% of the isolates from aerobic organisms and 18% anaerobic. He concluded that "wound colonization following dental extraction procedures in clean contaminated head and neck surgery increases the risk of anaerobic infections, and that the use of a therapeutic dose and possibly longer duration of perioperative antibiotics may be warranted (27)." Anesthesiology literature has emerged as another source of information for the use of perioperative antibiotics. Current anesthetic practice has an important influence on the prevention of surgical site infections and infectious risk. Keegan and Brown reviewed concepts involved in prophylaxis of SSI and discussed perioperative care provided by the anesthetic team that may alter the risk of infection, thus influencing patient outcomes. Increased surgical site infections occur more often when associated with older age, poor nutrition, obesity, smoking, diabetes, immunosuppresion, preoperative hospital stay, and colonization coexistent with infection, thus each patient should be reviewed on a case by case basis for prophylaxis. They also review procedure-specific current recommendations for antimicrobial prophylaxis and provide a composite list. Prosthetic joint replacements require cefazolin for 24 hours. Ophthalmic surgery guidelines indicate only antimicrobial eye drops for surgery involving the globe for prevention of postoperative endophthalmitis. Obstetric/ gynecologic recommendations include prophylaxis for 24 hours as well as otolaryngology surgeries excluding endoscopic sinus procedures. Neurosurgical guidelines include prophylactic 24 hour antibiotics for patients undergoing craniotomy as well as after penetrating cranial trauma. Thoracic/vascular/cardiac guidelines recommend antimicrobial prophylaxis for 24 hours with ancef with the exception of chest tube placement. Current urologic guidelines recommend prophylactic antibiotics if the patient has an indwelling catheter or bacteriuria. Colorectal procedures have guidelines supported by literature that reports positive results for single dose or short term use of a first-generation cephalosporin for antimicrobial prophylaxis. Some advocate the addition of metronidazole to cefazolin or the use of agents with extended gram-negative coverage (10). Keegan and Brown also highlight the importance of knowing the dosing/timing of antibiotic administration and not underestimating re-dosing principles of antibiotics depending on the EBL, half life of the agent, the volume distribution, or drug elimination properties. Simple operating room procedure has also been shown to decrease infection risk such as limiting the number of people in the operating room, proper scrub technique, antibiotic coated catheters and sterile technique of location and placement of intravascular devices by anesthesia personnel, temperature regulation to maintain normothermia, and glucose control (10).

Conclusion

The general principles of antisepsis that were introduced by Lister in the 1860s revolutionized the role that surgery had in curing disease and prolonging a patient's life. We have come a long way in decreasing patient morbidity and mortality with proper scrub practice, sterile operating room environment and equipment, and meticulous surgical technique. These facets of surgery, along with proper patient selection and procedure selection, as well as protocols of pre-operative bowel preps in abdominal surgery, remain the basic tenets of surgical site infection prevention. Antimicrobial prophylaxis was introduced as an adjunct to these tenets and remains as such today. There has been sufficient general surgery literature to support the use of single agent and short term prophylactic perioperative antibiotics to decrease the rate of surgical site infections. The topic remains an important one as surgical site infections remain a significant burden to the health care system by increasing costs of hospitals with increasing hospital stay and length of intensive care unit stay, as well as negatively impacting a patient's recovery and even mortality.

Trauma surgery cares for patients who frequently arrive to the hospital with imbedded foreign material such as bullets, metal, or debris from the scene of the injury. This patient population also represents those who enter surgery with an existing stressed metabolic state, one where proinflammatory mediators are abundant. This is most similar to general surgery patients who undergo emergent surgery. Thus there has existed a debate about the best way to utilize perioperative antibiotics in this patient population.

A review of the past thirty years of trauma surgery literature on the role of perioperative prophylactic antibiotic use is presented in this paper. Recommendations for perioperative antibiotic use in general trauma surgery mimics the data

for general surgery, which is the use of a single agent for a short 24-hour course perioperatively. A focus on abdominal trauma surgery revealed strong support for the same guidelines.

Thoracic trauma surgery literature also supports the use of prophylactic perioperative short course antibiotics when there is contamination of the sterile cavities of the chest and thorax, however rare this event may be. Though the EAST guidelines support the use of 24 hours of a first generation cephalosporin in the management of tube thoracostomy for traumatic hemopneumothorax, popular belief is that there is no benefit; thus Class I and II studies need to be performed. Differences exist within subspecialty departments such as otolaryngology, orthopaedics, oral and maxillofacial surgery, neurosurgery, and urology, to name a few, who are integrally involved in trauma patient care. There are wide differences in their respective literatures and many protocols are center-specific. A more uniform stand should be taken by the respective national academies of each group to provide more specific guidelines. As presented in our own institution, the implementation of a protocol to standardize prophylactic perioperative antibiotic use in trauma patients managed by the trauma surgery and oral and maxillofacial surgery departments resulted in more patients receiving only perioperative antibiotics without increasing our rate of infections. It should be a collaborative approach between multiple subspecialties to undertake the goals of defining protocols that will benefit the patient and assist caregivers.

This review article aimed to establish a pattern of recommendations supported by evidence based literature in trauma surgery. The long-term goal is that this can be used to establish center-specific protocols that may assist with patient care from a quality improvement perspective.

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