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Antibiotic prophylaxis in injury: an American Association for the Surgery of Trauma Critical Care Committee clinical consensus document

Rachel D Appelbaum ,[1] Michael S Farrell ,[2] Rondi B Gelbard,[3] J Jason Hoth,[4] Randeep S Jawa ,[5] Jordan M Kirsch,[6] Samuel Mandell,[7] Eden A Nohra ,[8] Tanya Rinderknecht,[9] Susan Rowell,[10] Joseph Cuschieri ,[11] Deborah M Stein [12]

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For numbered affiliations see end of article.

Correspondence to
Dr Deborah M Stein; dstein@som.umaryland.edu

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INTRODUCTION

As clinicians, we strive to use antibiotics selectively as there is increasing awareness of the importance of antibiotic stewardship and the risk associated with antibiotic overuse. In this clinical consensus document, the American Association for the Surgery of Trauma (AAST) Critical Care Committee aims to provide practical guidance to the surgical intensivist on the best practices in the assessment and prophylaxis of adult trauma patients, ≥16 years of age, at risk for infection due to their injuries sustained. These recommendations are summarized in tables 1 and 2.

METHODS

The AAST Critical Care Committee chose antibiotic management in the intensive care unit (ICU) as a clinically relevant topic for review. This document is one of a three-part TSACO series on this topic. The subtopics reviewed are not comprehensive for the topic of antibiotic management in the ICU but were specifically selected to be practical and useful for the surgical intensivist. A working group was formed from the committee at large to complete this work. The members of the working group were each assigned a subtopic to review using research to date. The members were asked to base their recommendations on research within the last 10 years. If research is unique, important, and has not been replicated, then it may be used even if it is older than 10 years. The research on which the recommendations are based was compiled at the discretion of the working group. Iterative selection of studies was not performed as in a systematic review, and the methodology of the literature search was at the discretion of the authors. Any topic with discrepant or minimal supporting literature was reviewed by the AAST Critical Care Committee with an anonymous survey. The recommendations were then reviewed by the AAST Critical Care Committee at large. Consensus was either achieved by conference or reported as 'no consensus'. The recommendations apply to adult trauma patients, ≥16 years of age. Clinicians must take into account other considerations such as weight and pregnancy for adjustments in dosing and specific antibiotic selection.

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The work therefore represents expert opinion and the recommendations of the entire committee. These recommendations are not intended to replace the provider's clinical experience. The responsible provider must make all treatment decisions based on their independent judgment and a patient's individual clinical presentation.

SPECIAL CONSIDERATIONS

Contamination

When choosing an antibiotic regimen, one must take into account special circumstances regarding the type of contamination involved such as salt water/freshwater, clostridial species, or pet/human bites. Water contamination requires coverage for *Vibrio*, *Aeromonas*, *Pseudomonas*, and other species. Trauma involving salt water should be treated with doxycycline and ceftazidime, or a fluoroquinolone. Freshwater wounds should be managed with ciprofloxacin, levofloxacin, or a third-generation or fourth-generation cephalosporin.[1] Potential clostridial contamination, such as farm-related injuries, requires high-dose penicillin irrespective of the fracture type.[2]

A full review of the treatment of bite injuries is beyond the scope of this document, but wounds caused by human, cat, and dog bites (the most common bite wounds encountered) are often treated with antibiotics due to the high load of more variable pathogens found in the oral cavity and the wound mechanism, with punctures that make both natural movement of the bacteria and adequate irrigation difficult.[3] A course of 3–5 days of amoxicillin-clavulanate is a suggested regimen, with clindamycin plus trimethoprim-sulfamethoxazole two times per day as an alternative for patients with a penicillin allergy.[4 5] While there is increasing question in the literature about the benefit of treating bite injuries with empiric antibiotics, there seems to be general consensus that injuries in high-risk locations (specifically hands, and over cartilage) and in high-risk patients should be treated.[4–6] Rabies treatment should also be considered and addressed with any mammalian bite wounds (table 1).

FACE AND SCALP

The evidence for prophylactic antibiotic use for traumatic injuries of the face is heterogeneous

Table 1 Contamination considerations

Type of contamination	Antibiotic recommendations	Additional considerations
Water contamination	Short course, 3–5 days Salt water ► Doxycycline and ceftazidime ► Fluoroquinolone Freshwater ► Ciprofloxacin ► Levofloxacin ► Third or fourth-generation cephalosporin	► *Vibrio* ► *Aeromonas* ► *Pseudomonas*
Soil contamination	Short course, 3–5 days ► High-dose penicillin	► *Clostridium* sp ► Farm-related injuries
Mammalian bites (human, dog, or cat)	Short course, 3–5 days ► Amoxicillin-clavulanate ► Clindamycin plus trimethoprim-sulfamethoxazole for penicillin-allergic patients	

and of fairly low quality, and there are no sufficiently powered randomized controlled trials on this topic. As a result, there is tremendous variability in practice patterns among treating surgeons, and many providers continue antibiotic prophylaxis longer than proposed, which leads to overuse of antibiotics in this patient population.[7 8]

The Surgical Infection Society (SIS) recently published a guideline for prophylactic antibiotic use in patients with traumatic facial fractures.[9] The authors of the SIS guidelines defined prophylactic antibiotics as antibiotics administered for more than 24 hours. This was further broken down into preoperative antibiotics (administered more than 1 hour before surgery or 2 hours if receiving vancomycin or quinolones), perioperative antibiotics (administered within 1 hour of surgery, but no more than 24 hours after surgery), and postoperative antibiotics (continued beyond 24 hours after surgery). We use these definitions for the recommendations outlined in this clinical consensus document.

Open or contaminated facial fractures

Are prophylactic antibiotics indicated in the setting of open or contaminated facial fractures?

Recommendations: Fractures of the frontal sinus that involve the posterior table, contaminated fractures, and open mandible fractures should receive 24 hours or less of antibiotics (table 2).

Discussion: Fractures that communicate with the oral cavity or dentate segment of the mandible (ie, angle, body, parasymphysis, and symphysis regions) are often considered open, contaminated wounds, and therefore may place patients at higher risk for osteomyelitis and other infectious complications.[10 11] Some studies have reported infection rates as high as 50% for open fractures in the absence of antimicrobial prophylaxis.[12] This has led to frequent utilization of antibiotic prophylaxis for these fracture patterns, especially among patients at high risk for infection-related complications (ie, immunosuppression), despite limited data to support this practice. Three small retrospective studies[13–15] and one single-center randomized study,[16] including patients with mandibular fractures, found that preoperative antibiotics were not associated with a reduction in infection or non-union rates. It is important to note that these studies were all limited by study design, lack of a control group, and inadequate reporting of open fractures.

Two randomized studies of facial fractures limited postoperative antibiotic administration to less than 24 hours which resulted in a significant reduction in infections compared with patients who received no antibiotics.[12 17] This may justify the use of antimicrobial prophylaxis until 24 hours after injury; however, continuation beyond this period is not recommended.[9] In a review of antibiotic prophylaxis in facial trauma by Goormans *et al*, none of the included studies found a statistically significant benefit of prolonging antibiotic prophylaxis beyond 24 hours.[18] In fact, some studies noted a significantly increased infection rate for patients who received antibiotic prophylaxis for more than 1 day.[19–21] In terms of the recommended antibiotic type, no studies have compared the effect of different types of antibiotics on infection rates so the most suitable antibiotic for maxillofacial trauma is unknown.

Closed, non-contaminated, operative facial fractures

Are prophylactic antibiotics indicated in the setting of closed, non-contaminated, operative facial fractures?

Recommendations: Non-contaminated, operative facial fractures do not require postoperative antibiotics.

Discussion: Fractures of the upper one-third of the face (including fractures of the frontal sinus that do not involve the posterior table), middle one-third of the face (including LeFort fractures, zygomaticomaxillary complex fractures, orbital fractures, maxillary sinus wall, and nasal bone fractures), and lower one-third of the face (non-dentate segments of the mandible) are considered non-contaminated fractures and have a lower frequency of postoperative infections.[18] Therefore, continuing prophylactic antibiotics beyond 24 hours after surgical fixation is not recommended without documented infection. This is based on findings from multiple studies of mandibular and non-mandibular fractures that found no significant difference in infection rates between patients who received preoperative or postoperative antibiotics versus those who did not.[22 23] In fact, one study concluded that a single dose of antibiotics at the time of induction (20 minutes before surgery) is sufficient.[24] Soong *et al* conducted a non-blinded randomized study comparing 1 versus 5 days of postoperative antibiotic use after zygomatic or LeFort fracture repair and found no difference in infection rate between groups.[25] The two more recent systematic reviews, one including 13 studies of mandibular and non-mandibular fractures,[26] and the other mandibular fractures only,[21] also found insufficient evidence to support the use of postoperative antibiotics beyond 24 hours. In fact, the use of antibiotics for >24 hours postoperatively is more costly and may lead to more antibiotic-associated complications.

Non-operative facial fractures

Are prophylactic antibiotics indicated in the setting of non-operative facial fractures?

Recommendations: Prophylactic antibiotics should not be administered for closed, non-operative orbital, upper face, midface, or mandibular fractures.

Discussion: The SIS recommends against the use of prophylactic antibiotics for non-operative facial fractures based on the results of two small retrospective studies[19 27] and one small single-center randomized study.[28] The study by Malekpour *et al* compared no antibiotics to a short course (1–5 days) or a long course (>5 days) of antibiotics on the incidence of facial soft tissue infection or *Clostridium difficile* colitis. There were no

Table 2 Summary of antibiotic recommendations

Injury	Antibiotic recommendations	Additional considerations
Face and scalp		
Open or contaminated facial fractures	Prophylactic antibiotics 24 h or less ► Cefazolin—coverage against GP bacteria ► Ceftriaxone—broader GN coverage and CNS penetration ► Ampicillin/sulbactam—broader GN and anaerobic coverage ► Clindamycin—for penicillin-allergic patients	► Frontal sinus fracture that involves the posterior table ► Contaminated fractures ► Open mandible fractures
Closed or non-contaminated operative facial fractures	Preoperative antibiotics ► Cefazolin—coverage against GP bacteria ► Ceftriaxone—broader GN coverage and CNS penetration ► Ampicillin/sulbactam—broader GN and anaerobic coverage ► Clindamycin—for penicillin-allergic patients No postoperative antibiotics	► Fractures of the upper one-third of the face ► Frontal sinus fractures that do not involve the posterior table ► Fractures of the middle one-third of the face (LeFort, zygomaticomaxillary complex, orbital, maxillary sinus, nasal bone) ► Fractures of the lower one-third of the face (non-dentate segments of mandible)
Non-operative facial fractures	No prophylactic antibiotics	► Orbital fractures ► Upper face fractures ► Mid-face fractures ► Mandibular fractures
Facial and scalp lacerations	Prophylactic antibiotics 24 h or less if complex or high-risk patient ► Amoxicillin-clavulanate ► Clindamycin—for penicillin-allergic patients	► Communication to oral cavity ► High infection risk: significant tissue destruction, large dead space, extensive contamination, underlying medical problems that place a patient at high risk (diabetes, immunosuppression, steroids, extremes of age, obesity, etc)
Nasal packing	No prophylactic antibiotics	
Central nervous system		
Pneumocephalus	No prophylactic antibiotics	► Associated with open skull fracture and communication to the sinuses
CSF leaks	No prophylactic antibiotics	► Associated with basilar skull fractures
Penetrating brain injury	Short course of prophylactic antibiotics, <3 days ► Cefazolin ► Clindamycin - for penicillin-allergic patients ► Visible contamination—add metronidazole	
Penetrating spine injury	Short course of prophylactic antibiotics, no more than 48 h ► First and second-generation cephalosporins ► Ampicillin-sulbactam ► Piperacillin-tazobactam ► Clindamycin with second-generation cephalosporin	► Gastrointestinal involvement, specifically transcolonic
Extremity		
Closed extremity fractures	No prophylactic antibiotics if non-operative management Preoperative antibiotics within 1 h of incision ► First-generation cephalosporin ► Clindamycin—for penicillin-allergic patients	
Open extremity fractures	Prophylactic antibiotics 24 h or less ► Types I and II should be treated with GP coverage First-generation cephalosporin Clindamycin - for penicillin allergic patients ► Type III should be treated with GP and GN coverage First-generation cephalosporin and aminoglycoside Piperacillin/tazobactam Ceftriaxone ► Antibiotics should be initiated within 1 h of injury and continued for 24 h	► Washout and debridement should take place within 24 h of injury
Soft tissue injury		
Soft tissue Lacerations/stab wounds	Prophylactic antibiotics 24 h or less if complex or high-risk patient ► First-generation cephalosporin ► Clindamycin—for penicillin-allergic patients	High-risk infection ► Specific wound-related concerns (presence of significant contamination, crush injury, or specific at-risk anatomic sites) ► Underlying patient factors that would increase the risk or worsen the outcome of infection
GSW	Prophylactic antibiotics 24 h or less if complex or high-risk patient ► First-generation cephalosporin ► Clindamycin—for penicillin-allergic patients	► Surgical debridement of devitalized tissue if needed ► Consideration of low-energy vs. high-energy mechanism

Continued

Table 2 Continued

Injury	Antibiotic recommendations	Additional considerations
Burn injury	No prophylactic antibiotics	

Providers should take into account their institutional antibiogram when choosing antibiotics for prophylaxis and/or treatment.
CNS, central nervous system; CSF, cerebrospinal fluid; GN, Gram-negative; GP, Gram-positive; GSW, gunshot wound.

soft tissue infections in any group. Mandibular and open fractures were excluded, limiting extrapolation to these groups. The study by Zosa *et al* included 403 patients and compared a short course (single dose or no antibiotics) to extended course (>24 hours) and found no difference in infection rate between treatment groups (3% vs. 5%).

Facial and scalp lacerations

Are prophylactic antibiotics indicated in the setting of facial and scalp lacerations?

Recommendations: Prophylactic antibiotics should be given for through-and-through lacerations from the skin to the oral cavity and in the setting of mammalian bites to the face. Prophylactic antibiotics should not be routinely prescribed for simple facial and scalp lacerations; however, 24 hours or less should be considered in cases with higher infection risk: wounds with significant tissue destruction, large dead space, extensive contamination, or patients with underlying medical problems that increase their risk of infection (table 2).

Discussion: Caruso *et al* wrote a detailed review of the evidence for prophylactic antibiotic therapy in traumatic craniomaxillofacial injuries in 2022, nicely summarizing the available literature.[4] Much of this discussion will draw from that review, as well as the Infectious Disease Society of America guidelines.[29] There is a general lack of adequate evidence to guide decision-making for these injuries, and Caruso *et al* appropriately counsel that thoughtful consideration of the patient, wound, and underlying pathophysiology must be used to make decisions when there is no clear guidance from the data. Compared with injuries to the rest of the body, injuries to the head and neck tend to have the lowest rates of infectious complications.[4] This is likely due to the excellent blood supply to this region of the body. For clinical scenarios of 'normal' risk (a simple wound in a healthy patient), prophylactic antibiotics do not confer a benefit and should not be used. However, wound characteristics (bites, farming injuries, crush injuries, gross contamination, devitalized tissue, etc) and patient characteristics (diabetes, immunosuppression, steroids, extremes of age, obesity, etc) need to be factored into an assessment of overall infection risk.

One concern with facial lacerations is potential communication with the oral cavity, which carries a significant bacterial load. Lacerations that are confined to the intraoral cavity (including mucous membranes, the lips, and the tongue) and do not communicate with the extraoral environment do not need antibiotics.[4 30] Through-and-through lacerations have been considered at higher risk for infection, and therefore antibiotics are often suggested, although this remains controversial given the limited data.[4 5 30 31] There are almost no specific data to inform antibiotic prophylaxis for scalp wounds specifically, so it seems reasonable to extrapolate from the management of other traumatic soft tissue wounds. Traumatic cartilage exposure (ear, nose) has historically been treated with prophylactic antibiotics (often fluoroquinolones) in addition to local wound care due to concern for perichondritis. Fluoroquinolones have been used because pseudomonas is a common cause of all-cause perichondritis, but most of these cases are related to piercings, and it is unclear whether the trauma population follows the same microbial pattern.[32 33] Evidence to support systemic antibiotics in these injuries is lacking.[4 34] Thus, as above, we think a practical approach would be to risk stratify the wound and the patient and use antibiotics only sparingly in truly high-risk situations.

Nasal packing

Are prophylactic antibiotics indicated in the setting of nasal packing?

Recommendations: Prophylactic antibiotics are not recommended in the setting of nasal packing for traumatic epistaxis given a lack of data showing benefit.

Discussion: Nasal packing material is often placed when other efforts at controlling epistaxis have failed. Packing can stay in place for an amount of time varying from a few hours to many days. Infectious concerns with nasal packing include rhinosinusitis, otitis media, and toxic shock syndrome.[35] However, multiple recent studies have found routine systemic antibiotic prophylaxis to be neither effective at reducing infection rates nor cost-effective given the risks and complications of antibiotics.[35–42] Rates of infection associated with nasal packing are very low at baseline, and cases of toxic shock syndrome secondary to nasal packing are almost non-existent from the last decade.[35 41 43] Due to this low infection rate, the many small studies that have attempted to study the role of empiric antibiotic prophylaxis are grossly underpowered to show any significant difference.

CENTRAL NERVOUS SYSTEM

Pneumocephalus

Are prophylactic antibiotics indicated in the setting of pneumocephalus?

Recommendations: Prophylactic antibiotics should not be used in patients with post-traumatic pneumocephalus.

Discussion: Traumatic pneumocephalus is defined as air within the cranial vault and is suggestive of an open skull fracture or communication with the sinuses. Pneumocephalus is often included in studies evaluating the utility of prophylactic antibiotics for basilar skull fractures. Randomized trials evaluating basilar skull fractures by Eftekhar *et al* and earlier by Hoff *et al* reported no advantage of the use of antibiotic prophylaxis in patients with traumatic pneumocephalus.[44 45] Recently, a large retrospective study evaluated the utility of different prophylactic antibiotic regiments for traumatic pneumocephalus. In addition to demonstrating central nervous system (CNS) infection to be very rare in the setting of traumatic pneumocephalus with an incidence of approximately 1%, the authors found no protective advantage to the use of antibiotic prophylaxis.[46]

Cerebrospinal fluid leaks

Are prophylactic antibiotics indicated in the setting of cerebrospinal fluid (CSF) leaks?

Recommendations: Prophylactic antibiotics are not recommended in patients with post-traumatic CSF leaks.

Discussion: As mentioned above, basilar skull fractures are thought to predispose patients to CNS infections due to possible

direct contact of bacteria in the paranasal sinuses, nasopharynx, or middle ear. CSF leakage has been associated with a greater risk of contracting meningitis, encephalitis, and ventriculitis. CSF leakage often presents clinically as rhinorrhea or otorrhea.[47] The incidence of meningitis in patients with post-traumatic CSF leaks varies widely with 10% being a generally accepted rate of infection.[47] Antibiotics are often given prophylactically, although their role in preventing bacterial meningitis has not been established. Eftekhar *et al* evaluated the use of ceftriaxone for meningitis prophylaxis in patients with basilar skull fractures.[45] Ceftriaxone has broader gram-negative coverage and CNS penetration. They found no difference in the incidence of meningitis between those who received antibiotics and those who did not when adjusted for the presence of CSF rhinorrhea or otorrhea. Similarly, Demetriades *et al* using ceftriaxone or ampicillin/sulfadiazine and Klastersky *et al* using penicillin G evaluated the incidence of meningitis in patients with basilar skull fractures and CSF leaks.[48 49] Again, no significant difference in the incidence of meningitis in the antibiotic groups was noted when compared with those who did not receive antibiotics. Lastly, in a Cochrane meta-analysis, no benefit with the use of prophylactic antibiotics was found in patients with basilar skull fractures with or without CSF leakage.[50] Ratilal *et al* found no difference in the frequency of meningitis, all-cause mortality, meningitis-related mortality, and need for surgical correction in patients with CSF leakage with the use of prophylactic antibiotics.[50]

Penetrating traumatic brain injury

Are prophylactic antibiotics indicated in the setting of penetrating traumatic brain injury (pTBI) to reduce the rate of CNS infection?

Recommendations: A short course of prophylactic antibiotics should be given for pTBI. An extended course of antibiotics, >3 days, does not appear to offer any benefit (table 2).

Discussion: pTBI carries a high risk of infection due to the presence of a foreign body entry into the brain parenchyma. Despite this, controversy continues to exist regarding the use of antibiotic prophylaxis in this patient population as no prospective, randomized data exist to guide management. In 1998, a collaborative effort between national and international traumatic brain injury experts recommended broad-spectrum antibiotics for patients with pTBI without specifying which antibiotic to administer or the duration of use.[51] Recent data call into question the benefit of prophylactic antibiotics for pTBI,[52 53] thus current recommendations remain inconsistent.

In 2020, Loggini *et al* performed a systematic review for the management of pTBI concluding that there are no robust data for prophylactic antibiotics.[54] In contrast to this recommendation, the US Department of Defense Centers for Excellence for Trauma recommends cefazolin or clindamycin for an unspecified duration. If the wound is visibly contaminated, the guideline suggests the addition of metronidazole.[55] The US Army Center for Surgical Research also recommends cefazolin for 5 days if there is gross contamination of the wound.[56] More recently, in 2023, Ganga *et al* performed a PRISMA systematic review to assess the impact of prophylactic antibiotics on reducing risk of CNS infection. The review included 327 cases in which 216 (66%) received prophylactic antibiotics. 38 of the 216 patients who received antibiotics developed infection compared with 21 (19%) who did not (p=0.76). The authors additionally included their institutional experience with 21 patients of which 17 received antibiotics and four did not. All four patients who did not receive antibiotics developed CNS infections, whereas only two out of the 17 with antibiotics (12%) developed infectious complications. The authors concluded that despite insufficient data to support antibiotic use in the literature, the institutional series may benefit from a short course of antibiotics with or without the presence of organic debris.[57]

The Brain Trauma Foundation (BTF) is the primary organization responsible for brain injury-related guidelines; however, they have not yet published guidelines related to the management of penetrating brain injury (including antibiotic prophylaxis). A Penetrating Brain Injury Expert Workgroup consisting of a collaboration between the BTF along with military and civilian experts has convened and guidelines to address this issue are expected to be published in the near future.[58] Thus, current recommendations are considerations based on military consensus and retrospective civilian studies. Antibiotic use for external ventricular drainage (EVD), ventriculoperitoneal (VP) shunts and their associated infection risk are discussed in the other articles in this series, Fever and Infections in Surgical Intensive Care and Surgical and Procedural Antibiotic Prophylaxis in the Surgical ICU by Nohra *et al*[59] and Farrell *et al*,[60] respectively.

Penetrating spine injury

Are prophylactic antibiotics indicated in the setting of penetrating spine injury?

Recommendations: Prophylactic antibiotics, no longer than 48 hours, are recommended for low-velocity gunshot wounds (GSW) to the spine (table 2).

Discussion: There has long been clinical concern regarding GSWs to the spine, especially those with gastrointestinal involvement, and the potential to develop spinal or paraspinal infections. As a result, much of the spine literature has advocated prolonged courses of 'prophylactic' antibiotics lasting up to 14 days to prevent infection with the greatest concern involving transcolonic injuries.[61] As no prospective studies exist, these recommendations are based on clinical judgment, older retrospective studies and case series that are underpowered and use varying antibiotic courses lasting up to 6 weeks. The incidence of infection without antibiotic use after penetrating injury is not known which further hampers the interpretation of any available information regarding the necessity or duration of antibiotic use. Additionally, there is very little information regarding stab wounds to the spine and the necessity of antimicrobial prophylaxis.

More recent studies have demonstrated a low incidence of spinal infection with a shorter duration of antibiotic use. In larger retrospective studies with adequate follow-up, Rabinowitz *et al* and Pasupuleti *et al* both demonstrated a very low rate of spine infection after transperitoneal, low-velocity GSWs to the spine including those with gastrointestinal involvement with courses of prophylactic antibiotic therapy lasting no more than 48 hours.[62 63] Admittedly, some patients received antibiotics for longer durations, but for treatment of infections acquired after admission unrelated to the spine. Antibiotics used in these studies included first and second-generation cephalosporins, ampicillin-sulbactam, piperacillin-tazobactam, and clindamycin with second-generation cephalosporins being used most commonly.

In another large retrospective study, Quigley and Place evaluated the incidence of spine infections after low-velocity GSWs.[64] Patients were separated into two groups with those receiving adequate (5 days) or inadequate (<5 days) prophylactic antibiotics, as described by the author. No information was provided regarding the antibiotics used. Spinal infections only occurred in those with gastrointestinal involvement; however, equivalent rates of spinal infection (12% vs. 15%) were noted irrespective

of the length of coverage. As such, the authors concluded a greater risk of infection with GSWs that involve the gastrointestinal tract and longer courses of therapy do not necessarily mitigate the risk. Earlier studies also support these findings.[65] A recent meta-analysis by Mahmood *et al* evaluated the duration of antibiotics for penetrating spine injuries and concluded that no formal recommendations could be made, but 48 hours appeared appropriate with the only possible exception being transcolonic injuries.[61] This caveat, however, is not supported by the findings of Rabinowitz and Pasupuleti. Ultimately, an adequately powered, prospective study that evaluates the necessity, type, and length of therapy is needed.

EXTREMITY

Are prophylactic antibiotics indicated in the setting of extremity fracture?

Recommendations: Closed extremity fractures require preoperative antibiotics within 1 hour of incision. Open extremity fractures should be graded based on the Gustilo classification system and treated with antibiotics based on the fracture severity. Types I and II should be treated with gram-positive coverage; while type III should be treated with gram-positive and gram-negative coverage. Antibiotics should be initiated within 1 hour of injury and continued for 24 hours. Washout and debridement should take place within 24 hours of injury. Antibiotics should not be continued >24 hours after soft tissue coverage. Depending on the type of contamination, the antibiotic regimen may need to be further adjusted (table 2).

Discussion: In 1976, Gustilo and Anderson created a system to classify open extremity fractures based on the size of the associated laceration, the degree of soft tissue injury, contamination, and presence of vascular compromise.[66] Gustilo *et al* refined the classification of severe open fractures, see box 1[67], and became the most common method to determine the type of antibiotics needed based on open fracture severity.[68] Type I fractures are those fractures from low-energy mechanisms, with <1 cm wounds and no gross contamination. Type II fractures are those with 1–10 cm wounds that lack gross contamination or extensive soft tissue damage, flaps or avulsions. Type III open fractures include those with wounds greater than 10 cm with extensive soft tissue damage, traumatic amputation, or any open fracture due to high-energy trauma (including high-velocity ballistic injuries), or any size wound with gross contamination.[66–68]

Closed fractures do not require antibiotics at presentation; however, preoperative antibiotics should be given within 1 hour of incision and first-generation cephalosporins are recommended.[69] All patients who sustain an open fracture, without a contraindication, should receive gram-positive antibiotic coverage within 1 hour of injury.[2] Additional gram-negative coverage should be added for type III fractures.[2 69] Fluoroquinolones offer no advantage compared with cephalosporin/aminoglycoside regimens.[2 70 71] Moreover, fluoroquinolones may have a detrimental effect on fracture healing and may result in higher infection rates in type III open fractures.[2 72 73] The preferred antibiotic for these fractures has typically been piperacillin/tazobactam due to its association with a lower risk of delayed wound healing.[74] However, recent data suggest that ceftriaxone monotherapy is an acceptable alternative.[2 75] Although some centers incorporate vancomycin into their prophylaxis algorithms for more severe fractures, the data supporting this practice are limited.

There is growing evidence that suggests the original 'six hour rule' for washout and debridement is based on historical perspectives, and numerous studies have failed to support this timeframe.[76 77] New evidence continues to show that washout and debridement of open fractures within 24 hours does not increase infectious complications.[78 79] Additional studies demonstrate no more than 24 hours of antibiotic coverage is required with many showing that a single dose of antibiotics prior to incision is sufficient.[80 81] The duration of antimicrobial coverage >72 hours does not further reduce the risk of infection, even in patients in whom soft tissue coverage has not been achieved.[2 82] Antimicrobials should be not be continued >24 hours beyond soft tissue coverage.[2]

Box 1 Gustilo classification

- ⇒ Type I
  - ⇒Open fracture with skin wound ≤1 cm, clean.
- ⇒ Type II
  - ⇒Open fracture with wound 1–10 cm, without extensive soft tissue damage, flaps, or avulsions.
- ⇒ Type III
  - ⇒Open fracture with wound >10 cm, with extensive soft tissue injury or amputation.
  - ⇒IIIA
    - ⇒Adequate tissue for flap coverage.
    - ⇒Farm injuries (at least Gustilo IIIA).
  - ⇒IIIB
    - ⇒Significant soft tissue loss with exposed bone that requires soft tissue coverage.
  - ⇒IIIC
    - ⇒Associated vascular injury requiring vascular repair, regardless of degree of soft tissue injury.

SOFT TISSUE INJURY

Of note, the focus of this section is on civilian trauma, with the acknowledgment that military-grade (ie, higher energy) weapons are sometimes used in civilian trauma. Further, this review will focus on isolated soft tissue injuries that are not associated with underlying bony or hollow viscus injury.

Simple lacerations (other than face and scalp)

Are prophylactic antibiotics indicated in the setting of simple lacerations?

Recommendations: Prophylactic antibiotics are not suggested in simple soft tissue lacerations. The exceptions to this recommendation are specific wound-related concerns or underlying patient factors that would increase the risk in which 24 hours or less of antibiotics would be appropriate (table 2).

Discussion: There are no recent data to support prophylactic antibiotics for uncomplicated, traumatic soft tissue lacerations. Most high-quality evidence on this topic is over 20 years old, and supports avoiding antibiotics,[5 6] while much of the recent literature is focused on soft tissue injury with underlying open fractures but does not address isolated soft tissue injury.[83] Overall, the studies emphasize the importance of adequate irrigation, debridement, removal of foreign bodies, and appropriate closure technique as the major means of infection prevention. While the little data that exist generally support forgoing antibiotic prophylaxis, it is important to identify the cases that are more complex and thus may have different management considerations. Moran *et al*[3] provide a useful approach, advising the consideration of both high-risk wounds and high-risk patients,

which may affect a clinician's decision to give antibiotic prophylaxis. The WHO provides a similar framework for wound assessment that includes size, contamination, and other high-risk factors.[84] Clinicians should work from a baseline understanding that in most simple, traumatic soft tissue wounds in civilian patients, prophylactic antibiotics are likely unnecessary, and then adjust only on the basis of specific patient-related or wound-related risk factors or concerns. Additionally, tetanus status should be queried and addressed.

Stab wounds

Are prophylactic antibiotics indicated in the setting of stab wounds?

Recommendations: Prophylactic antibiotics are not suggested in simple stab wounds that involve only soft tissue. The exceptions to this recommendation are specific wound-related concerns or underlying patient factors that would increase the risk in which 24 hours or less of antibiotics would be appropriate (table 2).

Discussion: Stab wounds can range from small but deep lacerations to more shallow wounds akin to simple lacerations. They are caused by objects of variable cleanliness. Like all wounds, irrigation and debridement of any devitalized tissue are paramount for infection prevention. Adequate irrigation of the deepest portions of stab wounds can be challenging without extension of the skin defect, and opening the wound further may require sedation or a trip to the operating room. This added morbidity must be weighed against potential benefit. Deeper wounds are at higher risk of infection.[85] The nature of the penetrating object, if known, as well as the extent and type of contamination, might sway a clinician's decision about antibiotics if there is a particular concern (eg, contamination with soil or aquatic microbes). Stab wounds that communicate with deeper body cavities or structures are generally managed based on the underlying injury. As mentioned above, tetanus status should be queried and addressed.

Gunshot wounds

Are prophylactic antibiotics indicated in the setting of GSWs?

Recommendations: The data are inconclusive regarding the risk of infection with low-velocity GSWs; hence, we recommend careful consideration of antibiotic prophylaxis for these wounds. Factors such as amount of tissue destruction, extent of contamination, timing since injury, anatomic location of the wound(s), and muzzle velocity, among others, may increase infectious risk enough to warrant antimicrobial prophylaxis for one or more systemic doses. Appropriate local wound management in accordance with these factors is a key principle in management (table 2).

Discussion: A popular myth is that the heat produced by the bullet kills bacteria—it does not; the bullet is contaminated, especially wadding in the setting of shotguns.[86–88] After GSW, substantial quantities of aerobic and anaerobic organisms have been reported in wounds after several hours.[87] Adequate surgical wound management is essential; however, it remains unclear whether empiric antibiotic prophylaxis improves infectious outcomes. Nguyen *et al* illustrated the lack of clarity in this realm with a survey of orthopedic trauma association members on the management of GSWs without underlying fractures.[89] One study, although underpowered, included 60 low-velocity GSW injuries to the extremities and demonstrated a relatively high 26% infection rate without antibiotics versus 6% infection rates with prophylactic antibiotics.[90] Others indicate lower infection rates that may be further reduced with antibiotics.[86 87]

While the literature is inconclusive for low-energy wounds, there is support for prophylactic antibiotic usage when wounds are complex, are of higher energy, have anatomic location such as hands/feet, and/or have other high-risk features mentioned above.[86 87] Higher energy GSWs are associated with increased infection rates, at least in part because the increased mass of devitalized tissue creates an excellent medium for bacterial growth without full host defenses. For high-energy wounds, 24–72 hours of systemic antibiotics have been recommended.[86 89 91] However, previous studies have indicated that only in a fraction of cases could the type of weapon be accurately determined,[87] so ultimately most of these judgments must rely on examination of the wound. This led to the axiom to treat 'the wound and not the weapon' from Lindsey.[92] Even if the degree of tissue contamination and tissue destruction merit antibiotic prophylaxis, antibiotics alone, without adequate debridement, would be insufficient.[86] When antibiotic prophylaxis is determined necessary for lower energy GSWs, a first-generation cephalosporin (or clindamycin in the setting of a penicillin allergy) generally is sufficient.[93] Appropriate duration is unclear and likely needs to be determined based on the same considerations described above.[90 94] Tetanus vaccination status should be addressed.[87]

BURN INJURY

Are prophylactic antibiotics indicated in the setting of burn injury?

Recommendations: Routine use of prophylactic antibiotics is not recommended for burn patients.

Discussion: Burn injury results in a massive inflammatory response as well as the loss of physical barriers (skin and airway mucosa) to infection. Bacterial translocation from the gut contributes to the risk of sepsis.[95] These risks have led to a continued interest in the use of prophylactic antibiotics for burn patients in the ICU; however, the practice remains controversial. In 2010, Avni *et al* published a meta-analysis demonstrating reduced all-cause mortality based on five studies.[96] There was a reduced rate of pneumonia based on four studies, but no overall effect on bacteremia. The included studies spanned approximately 40 years and were of relatively low quality. Perhaps more important was the significant increase in resistant organisms after prophylactic antibiotics. Subsequent meta-analyses in 2013, 2017, 2020 and one of pediatric patients in 2019 failed to show a benefit to systemic prophylaxis for the prevention of mortality.[6 97–99] In each of these studies there was significant variation in the type of prophylaxis used as well as the overall severity of the burns. While there is some evidence for the reduction of mortality in severely burned patients requiring mechanical ventilation with prophylactic antibiotics, no difference was found in patients not mechanically ventilated, and the effects on antibiotic resistance remain unknown.[98 100] Many consensus statements also agree that routine systemic prophylaxis should not be used in burn patients.[101–103]

Author affiliations
[1]Department of Surgery, Vanderbilt University Medical Center, Nashville, Tennessee, USA
[2]Department of Surgery, Lehigh Valley Health Network, Allentown, Pennsylvania, USA
[3]Department of Surgery, University of Alabama at Birmingham, Birmingham, Alabama, USA
[4]Department of Surgery, Wake Forest University School of Medicine, Winston-Salem, North Carolina, USA
[5]Department of Surgery, Stony Brook University, Stony Brook, New York, USA
[6]Department of Surgery, Westchester Medical Center, Valhalla, New York, USA

[7]Department of Surgery, University of Texas Southwestern Medical Center, Dallas, Texas, USA
[8]Department of Surgery, University of Colorado, Denver, Colorado, USA
[9]Department of Surgery, UC Davis Health, Sacramento, California, USA
[10]Department of Surgery, The University of Chicago Medicine, Chicago, Illinois, USA
[11]Department of Surgery at ZSFG, University of California San Francisco, San Francisco, California, USA
[12]R Adams Cowley Shock Trauma Center, University of Maryland, Baltimore, Maryland, USA

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ORCID iDs
Rachel D Appelbaum http://orcid.org/0000-0002-6401-4060
Michael S Farrell http://orcid.org/0000-0001-7665-2775
Randeep S Jawa http://orcid.org/0000-0002-4482-4699
Eden A Nohra http://orcid.org/0000-0001-9978-384X
Joseph Cuschieri http://orcid.org/0000-0003-1456-6841
Deborah M Stein http://orcid.org/0000-0003-3683-3963

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