



Infection prevalence and patterns in self-inflicted gunshot wounds to the face

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Objective. Self-inflicted gunshot wounds (SIGSWs) to the craniomaxillofacial region are uncommon injuries but are associated with a high mortality rate. Therefore, treating these patients is a rare occurrence even in the largest trauma centers. As with many rare conditions, data specifically addressing this injury pattern are scarce. Because of the proximity of the blast, even low-velocity injuries can be associated with significant avulsion of tissue, comminution of structures, and tissue die back. Previous case reports have recommended the use of prophylactic antibiotics, but no study has specifically investigated the postinjury infection rate or microbial patterns in this patient population. The purpose of this study was to answer the following clinical question: “Among patients with SIGW to the maxillofacial region, what is the prevalence of postinjury infection, and are there any microbial patterns that can guide empiric antibiotic selection?”

Study Design. We designed retrospective cohort study at a level I trauma center in Portland, Oregon. Data on 17 patients who had sustained a SIGSW involving the maxilla or the mandible and survived their initial injury were collected from 2010 to 2017.

Results. Patients who had a culture-positive infection within 30 days of their injury were defined to have a postinjury infection. Six of the 17 patients (35%) developed a postinjury infection, with an average time to infection of 11 days from initial injury (range 3–19 days). Of the 17 subjects, 15 (88%) received a course of prophylactic antibiotics, on average, for 14 days (range 3–24 days). Of the 6 cases of postinjury infection, culture grew gram-negative bacteria in 4 cases—anaerobic bacteria in 2 and polymicrobial organisms in 2. There was no clear pattern or prevalence of any specific bacterium, but cultures notably included *Staphylococcus aureus*, *Enterobacter* species, *Bacteroides* species, and *Escherichia coli*.

Conclusions. SIGSWs are associated with a high rate of postinjury infection (35%) despite prophylactic antibiotic usage in 88% of these cases. Given the antimicrobial patterns observed in this study, prophylactic antibiotics in this patient population should include empiric coverage for gram-negative and anaerobic bacteria. (Oral Surg Oral Med Oral Pathol Oral Radiol 2019;128:9–13)

Self-inflicted gunshot wounds (SIGSWs) to the craniomaxillofacial region are uncommon injuries but are associated with a high mortality rate. Thus, treating these patients is a rare occurrence even at the largest trauma centers. As with many rare conditions, there is little data specifically addressing this injury pattern. As a result, management is based on expert opinion and logically generalized surgical principles.

Gunshot wounds (GSWs) are classically subdivided into low velocity (<1200 ft/sec) or high velocity (>1200 ft/sec) injuries, depending on the causative firearm. The true determinant of injury is kinetic energy that is transferred to the tissue, but velocity has a well-defined squared relationship to kinetic energy, which typically makes velocity the biggest determinant in tissue

damage.^{1,2} However, SIGSWs combine the kinetic energy of the bullet with the blast injury from the muzzle itself.³ In the authors’ experience, even low-velocity injuries can be associated with significant tissue avulsion, which is classically a hallmark of high-velocity wounds. High-velocity SIGSWs are even more devastating and often require extensive reconstruction with free tissue transfer. Finally, SIGSWs to the maxillofacial region create an inherently dirty wound cavity as a result of its communication with the oral cavity and paranasal sinuses, in addition to the impregnation of soft tissue by fragmented bullet material. These factors make SIGSWs to the maxillofacial region a unique injury pattern, which can complicate generalizing principles and data from other types of GSWs.

In the past, experts have recommended empiric antibiotic coverage for GSWs to the head and neck, but no prior reports have focused on the prevalence of infection or the microbial patterns associated with these

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Statement of Clinical Relevance

Self-inflicted gunshot wounds to the craniomaxillofacial region are uncommon injuries but are associated with a high mortality rate. As with many rare conditions, there is little data to directly guide clinical management of these injuries.

injuries.^{4,5} These patterns and their implications have been investigated in extremity GSWs; however, we do not feel that these recommendations are readily generalizable to SIGSWs to the maxillofacial region because of the aforementioned factors.^{6,7}

The purpose of this study was to answer the following clinical question: “Among patients with SIGW to the maxillofacial region what is the prevalence of post-injury infection, and are there any microbial patterns that can guide empiric antibiotic selection?”

MATERIALS AND METHODS

Sample

This was a retrospective cohort study. The sample was derived from the population of patients presenting to the level I trauma center, Legacy Emmanuel Hospital, in Portland, Oregon, between 2010 and 2017 with a SIGSW. Subjects were included in the sample if they sustained a SIGSW involving the maxilla or the mandible and survived to be discharged home. No subjects who met these inclusion criteria were excluded from the analysis. The study protocol underwent institutional review by the institutional review board at Legacy Emmanuel Hospital, Portland, Oregon. The guidelines set forth by the Declaration of Helsinki on ethical principles for research involving human subjects were followed.

Study variables

The study variables included patient age and gender, anatomic location of injury, presence and type of prophylactic antibiotics, onset of infection, culture speciation, and culture sensitivities. For the purposes of this study, an “injury-related infection” was defined as a culture-positive infection occurring within 30 days of the initial injury. “Prophylactic antibiotics” were defined as antibiotics initiated within 8 hours of admission and continued for greater than 48 hours without evidence of active infection.

RESULTS

Over the 8-year study period from 2010 to 2017, 25 patients presented to the Legacy Emmanuel Hospital Emergency Department in Portland, Oregon, with SIGSWs to the head or neck and survived until discharge. Of these 25 cases, 17 involved the maxilla, the mandible, or both and were, therefore, included in the analysis. The demographic characteristics, location of injury, prophylactic antibiotic regimen and duration, time to infection, and culture data of all 17 subjects are summarized in Table I. The table is divided into 2 parts—the upper half listing those who did not develop an infection and the lower half those who did. The average age of these 17 patients was 43 years (range 15–71 years). There was a strong male predominance, with 14 males and 3 females. In 6 (35%) of the 17 patients a postinjury infection, defined as a culture-

positive infection occurring within 30 days of injury, developed. The average time to onset of infection was 11 days (range 3–19 days).

Of the 17 patients, 15 (88%) received a prophylactic antibiotics course, defined as antibiotics administered within 8 hours of admission and continued for greater than 48 hours without evidence of active infection (Table II). The choice of a specific antibiotic and duration of administration were determined by the attending physician at the time of the injury and are retrospectively reported here. Ampicillin and sulbactam were the most common prophylactic antibiotic agents selected (53%). In patients who did receive a course of prophylactic antibiotics and did not develop an infection, the average duration of antibiotic administration was 14 days (range 3–24 days). Of the 15 subjects who did receive prophylactic antibiotics, a postinjury infection developed in 5. Of the 2 subjects who did not receive prophylactic antibiotics, a postinjury infection developed in 1. Of the 6 cases of postinjury infection, the cultures grew gram-negative bacteria in 4—anaerobic bacteria in 2 and polymicrobial organisms in 2. There was no clear pattern or prevalence of any specific bacterium, but cultures notably included *S. aureus*, *Enterobacter* species, *Bacteroides* species, and *E. coli* (see Table I). The culture sensitivity data were reviewed and compared with the prophylactic antibiotic regimen data, and no patient developed an infection with bacteria sensitive to the prophylactic antibiotic regimen.

DISCUSSION

The overall prevalence of postinjury infection was 35% despite 88% of patients receiving some form of empiric antibiotic prophylaxis (see Table I). The prevalence of postinjury infection seems concordant with the findings of Vásconez et al.’s study, which found an incidence of 38% and 30% for delayed and immediate reconstruction groups, respectively, in a retrospective review of 33 high-energy GSWs to the face.⁸ Other reports often group infection with other complications and simply report on an overall complication rate.^{4,9} This high prevalence rate of infectious complications despite most sources reporting the use of some form of empiric antibiotic prophylaxis conflicts with the prevalence rates reported in the trauma literature on GSWs to other areas. A large review by Ordog et al. of 16,892 patients suffering minor GSWs that could be managed on an outpatient basis reported an infection rate of only 1.8%.⁶ A large systematic review in the orthopedic literature by Papasoulis et al. reported a 1.9% overall infection rate of fractures as a result of GSW, but no significant difference in the infection rate with the use of prophylactic antibiotics. Both these studies reported much lower rates of infections in the extremities compared with the maxillofacial region.

Given the prevalence of infections occurring after SIGSWs to the maxillofacial region and the wide

Table 1. Demographic characteristics, location of injury, prophylactic antibiotic regimen and duration, time to infection, and culture data of all 17 subjects*

Subject	Age (years)	Gender (M/F)	Injured structures	Prophylactic antibiotics	Duration of antibiotics (days)	Time to infection (days)	Culture data
1	44	M	Maxilla, mandible	Ampicillin + Sulbactam	11	n/a	n/a
2	41	M	Cranium orbit, maxilla, mandible	None	n/a	n/a	n/a
3	30	M	Cranium orbit, maxilla, mandible	Ampicillin + Sulbactam	3	n/a	n/a
4	35	M	Mandible, maxilla	Cefazolin	24	n/a	n/a
5	62	F	Maxilla, mandible	Ampicillin + Sulbactam	20	n/a	n/a
6	48	F	Maxilla, mandible	Cefazolin > Cefepime	22	n/a	n/a
7	15	M	Mandible	Ampicillin + Sulbactam	11	n/a	n/a
8	46	M	Cranium, maxilla, mandible	Ampicillin + Sulbactam	13	n/a	n/a
9	76	M	Orbit, maxilla	Ampicillin + Sulbactam	9	n/a	n/a
10	53	F	Orbit, maxilla, mandible	Ampicillin + Sulbactam	14	n/a	n/a
11	29	M	Orbit, maxilla, mandible	Ceftriaxone + Metronidazole > Clindamycin	11	n/a	n/a
12	60	M	Mandible	Ampicillin	29	19	<i>Escherichia coli</i>
13	28	M	Orbit, maxilla, mandible	None	n/a	7	<i>Enterococcus</i> species, <i>Haemophilus influenzae</i> , <i>Streptococcus anginosus</i> , <i>Streptococcus viridans</i> , <i>Bacteroides</i> species
14	32	M	Cranium, maxilla, mandible	Ampicillin + Sulbactam	10	3	Coagulase negative <i>Staphylococcus</i> , <i>Propionibacterium</i> , <i>Peptostreptococcus</i>
15	40	M	Maxilla, mandible	Cefazolin	24	9	<i>Enterobacter aerogenes</i>
16	71	M	Orbit, maxilla, mandible	Ampicillin	16	8	<i>Staphylococcus aureus</i>
17	19	M	Maxilla, mandible	Ampicillin + Sulbactam	32	19	<i>Enterobacter cloacae</i>

*The table is divided into 2 parts, the upper half listing those who did not develop an infection and the lower part those who did. *Location of injury* defined as a categorical value—mandible, maxilla, orbit, and cranium. *Prophylactic antibiotics* defined as antibiotics received within 8 hours of admission continued for greater than 48 hours without evidence of active infection. *Time to infection* defined as days from injury until the collection date of the positive culture.

Table II. Choice of prophylactic antibiotic*

Prophylactic antibiotics	n (%)
Ampicillin + Sulbactam	9 (53%)
Cefazolin	3 (18%)
Ampicillin	2 (12%)
Ceftriaxone + Metronidazole	1 (6%)
None	2 (12%)

*Prophylactic antibiotics defined as antibiotics received within 8 hours of admission continued for greater than 48 hours without evidence of active infection.

acceptance of the use of prophylactic antibiotics, a discussion regarding the indication for prophylactic antibiotic coverage is warranted. Although prior reports agree on the recommendation for prophylactic antibiotic coverage, none comments on a specific regimen, nor do any comment on the culture data from reported infections. The culture data available for report here is limited (see Table I) but still warrants examination. One hypothesis for the increased rate of infection seen in GSWs to the maxillofacial region compared with those to the extremities would be the common involvement of the inherently bacteria-laden oral cavity and paranasal sinuses. If this is a contributing factor, it would seem logical to cover common oral bacterial flora, including anaerobes. The data reported here demonstrate 2 of the 6 cultures with growth of anaerobic bacteria, including: *Peptostreptococcus*, *Bacteroides* species, and *Propionibacterium*. In light of this, we recommend empiric anaerobic coverage in a prophylactic regimen. In addition, 4 of the 6 cultures contained gram-negative bacteria, supporting the inclusion of empiric coverage of gram-negative bacteria. In our study, there was only 1 case of *S. aureus*. We do not believe that routine empiric coverage for methicillin-resistant *S. aureus* is indicated but we think it should be considered on the basis of the severity and location of the injury and the patient's comorbidities.

The duration of prophylaxis with antibiotics also warrants consideration. Of the previous reports that recommended a prophylactic course of antibiotics, none discussed a specific duration.^{4,5} Unfortunately, because of the design of this study, we are unable to comment on the relative effectiveness of different durations. Observationally, of the 6 recorded infections in this study, 4 occurred within 10 days, with an overall average time to infection of 11 days (see Table I). This seems to indicate that these patients are at the highest risk for developing infection in the first 2 weeks after their injury. Given the high rate of infection associated with these injuries, we feel that this patient population warrants the use of a prophylactic course of antibiotics, but a data-driven recommendation on the duration is not yet available. The timing and approach to reconstruction of these wounds is

a topic unto itself; however, we would recommend the continuation of antibiotics, even if an early reconstruction is performed. The Centers for Disease Control and Prevention guidelines do not recommend routine postoperative antibiotics for clean-contaminated wounds in the head and neck region.¹⁰ However, the evidence for the use of postoperative antibiotics in microvascular free tissue transfer in the head and neck region is less clear.¹¹ Regardless of the type of reconstruction performed, we believe that these wounds, despite undergoing routine washout and debridement, never achieve a clean-contaminated state and are at a high enough risk for infection; postoperative antibiotic use is, therefore, warranted, should the patient undergo early reconstruction.

This study has some limitations. First, it is retrospective, and given the prevalence of the use of prophylactic antibiotics, no statement or analysis can be made with regard to the impact of a prophylactic antibiotic regimen on the rate of infection after SIGSWs. Specifically, in this study, given that 15 patients received prophylactic antibiotics and only 2 did not, reporting any statistical comparison between the 2 groups, that is, comparing the 15 subjects who received prophylactic antibiotics with the 2 that did not, would be invalid and misleading. Second, the sample size makes any subgroup analysis statistically inappropriate. As a result, high-velocity and low-velocity injuries were subdivided, and we are unable to comment on their potential impact on infection prevalence or microbial patterns. We hope that the reader interprets these data appropriately, considering that this is a retrospective observational report of a rare entity and that the data may be able to provide some anecdotal support to a field that is largely managed by expert opinion and generalized knowledge from known surgical principles.

CONCLUSIONS

SIGSWs are associated with a high rate of postinjury infection (35%) despite 88% of these patients receiving prophylactic antibiotics; this rate is significantly higher than the rates for GSWs in other areas of the body. We feel that this warrants the routine use of prophylactic antibiotics in conjunction with timely washout and debridement of the wound. Culture data from these reported infections included anaerobic bacteria, gram-negative bacteria, and *S. aureus*. We recommend a course of prophylactic antibiotics with empiric anaerobic and gram-negative coverage for all patients who suffer SIGSWs to the maxillofacial region for a duration of 10 to 14 days from the time of injury. Routine empiric coverage for methicillin-resistant *S. aureus* is not indicated but should be considered on a case-by-case basis, depending on the severity and location of the injury and the patient's comorbidities.

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