Microorganisms and Infection Epidemiology after Gunshot Orthopaedic Trauma

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INTRODUCTION: Firearm related injuries constitute a significant morbidity in the United States with more than 80,000 Emergency Department (ED) visits per year between 2009-2017 with and increased incidence during the COVID-19 pandemic.[1,2] Reported rates of infection following gunshot wounds (GSWs) vary widely based on wound location, velocity, and extent of vascular involvement. In low-velocity wounds to the extremity, infection rates range from 1.8% - 15.7% with differing findings on the efficacy of prophylactic antibiotics.[3–7] A systematic review by Sathiyakumar et al. found heterogeneity in the recommended treatment both in administration of prophylactic antibiotics and extensive versus superficial debridement in low velocity gunshot wounds.[8] There is a paucity of literature examining the epidemiology and characteristics of the microorganisms involved in gunshot wound infections. Case reports and anecdotal traumatologist consensus depict a pattern of atypical microorganisms in gunshot wounds as compared to nonpenetrating traumatic injury.[9–12] The aim of this study was to characterize rates of infection, associated microorganisms, and antimicrobial treatment following low-velocity ballistic fractures in a large urban trauma center.

METHODS: A retrospective chart review using data from a level 1 trauma center was utilized. Patients with low velocity ballistic fractures were reviewed for variables including age, gender, fracture location, OTA classification, concomitant visceral and/or vascular injury, compartment syndrome, early antibiotic administration, and presence of infection. Early antibiotic administration (EAA) was defined as administration of antibiotics within 3 hours of presentation, and infection was defined according to Fracture Related Infection (FRI) census guidelines including a positive culture, return to OR for infection, or purulence from a wound or implant site. Patients found to have an infection were further included in a subgroup analysis. Variables in the subgroup review included diabetes, most recent a1c (if diabetic), tobacco use, microorganism(s) species, time to infection (from presentation), time to microbial eradication, and antibiotic regimen. Patterns of microorganism growth and antibiotic regimen in the infection subgroup are descriptively reported.

RESULTS:

A total of 398 patients presenting between May 1, 2018 and December 1, 2019 were included. The average age was 28 years with an 89.4% male (n=356) cohort. Overall, 24 patients (6%) developed an infection during their clinical course. In total, 60.8% of patients received EAA with no significant difference in infection between patients receiving EAA vs. no EAA (OR = 1.05, 95% CI 0.45 – 2.46, p = 0.91). The most common antimicrobial given upon presentation was cefazolin (61% of EAA doses). Orthopaedic surgery was performed on 186 patients (46.7%), most commonly open reduction and internal fixation (ORIF). Of patients undergoing orthopaedic intervention, 19 patients (10.2%) developed an infection in their clinical course. The overall most common ballistic fractures were femur and ankle fractures while patients experienced significantly higher rates of infection following tibia fracture (21.4%, p = 0.032) (Figure 1). In the infection subgroup, 4 patients (16.6%) were diabetic, and 10 patients (41.6%) reported tobacco usage. The mean time from injury to first positive culture was 22.1 days (range: 5 days – 33 days) with polymicrobial infection in 18 patients (75%). The median time from initial positive culture to resolution based on negative culture was 12 days (IQR = 7 – 18 days). The most common pathogens included methicillin resistant *Staphylococcus aureus,* Group A streptococcus, and *Candida albicans* (Table 1). The most common antimicrobial treatment following diagnosis of infection included intravenous (IV) vancomycin in 17 patients (70.8%), IV cefepime in 10 patients (41.6%), oral ciprofloxacin in 6 patients (25%), and IV fluconazole in 6 patients (25%).

DISCUSSION AND CONCLUSION: In our cohort of low velocity ballistic fractures, 24 patients (6.0%) developed an infection during their treatment. We define the microbial profile in ballistic fracture infections and profiles of location and bacteriology. Pathogens in the infection subgroup demonstrated several notable features including numerous multi-drug resistant pathogens and rare pathogens with intrinsic resistance to current antimicrobial treatment such as *Candida parapsilosis* and *Fusarium*. The findings of this study suggest atypical, and less responsive bacteria may affect the utility of conventional prophylactic antibiotics after low velocity ballistic fractures; however, additional understanding of the microbiology is required.

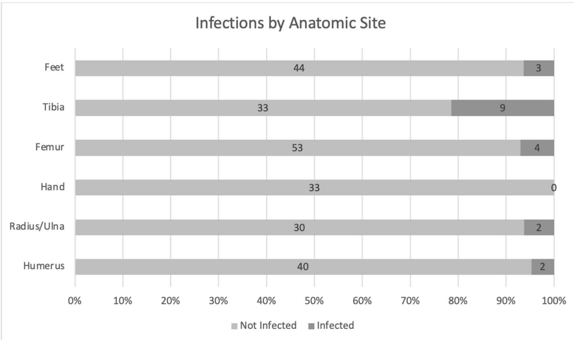

Figure 1: Overall Fractures and Fracture-Related Infections by Anatomic Site

Organism	Patients (%) n=24	Mean Time to Growth* (days)	Culture Site (#)
Bacteria			
methicillin resistant *Staphylococcus aureus*	11 (45.8)	24	Blood (4), LE (4), UE (3)
Group A *Streptococcus*	5 (20.8)	8	LE (4), UE (1)
Pseudomonas aeruginosa	4 (16.6)	14	LE (2), Pelvis (1), Blood (1)
Enterobacter faecalis and *cloacae*	3 (12.5)	13	Blood (2), Spine (1)
Cornyebacterium striatum	1 (4.2)	17	LE (1)
Fungi			
Candida albicans	5 (20.8)	12	LE (3), Blood (1), ME (1)
Aspergillus fumigatus	3 (12.5)	11	Pelvis (1), Spine (1), Blood (1)
Candida parapsilosis	1 (4.1)	14	LE (1)
Rhizopus oryzae	1 (4.1)	13	ME (1)
Fusarium solani	1 (4.1)	9	ME (1)

Table 1: Pathogen Characteristics in Infection Subgroup
*Time to growth calculated from initial ballistic injury
LE = Lower Extremity, UE = Upper Extremity, ME = Multiple Extremity