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ORIGINAL ARTICLE • HAND - FRACTURES

Treatment of open fractures of the hand in the emergency department

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Abstract Current guidelines suggest early surgical treatment of open fractures. This rule in open hand fractures is not well supported and may be unpractical. Furthermore, desirable debridement and washout can be obtained in the emergency department (ED). The purpose of this study was to evaluate the relationship between the level of contamination, quality of washout in the emergency room, and the development of infection. Sixty-one patients with open fractures of the hand were retrospectively reviewed for demographic and fracture characteristics, and other complications. The infection rate was 14.8%. Contamination was present in 43 patients (70.5%). One thousand milliliters or more were used to obtain a grossly clean wound in 43 patients (70.5%). No significant relationship was found between fracture type, finger involved, hand dominance, comorbidities, and development of infection. The amount of fluid used for washout was significantly related to infection ($P = 0.047$), whereas wound contamination was not ($P = 0.259$). Type of oral antibiotic was significantly related to infection ($P = 0.039$). The level of contamination was not a significant factor in predicting infection, whereas the amount of fluid used for washout and the oral antibiotic type were significant factors in preventing infection. Since administration of intravenous antibiotics and thorough wound cleansing can be performed on open hand fractures in the ED under adequate anesthesia, most open fractures in the hand do not need to be treated early in the operating theater.

Keywords Debridement · Emergency department · Infection · Lavage · Open fracture

Introduction

Fractures of the hand are commonly open injuries, involving the soft tissues to varying degrees [1, 2]. With an infection rate in the literature of up to 11%, they have an increased risk of complications such as nonunion, stiffness, neuropathy, amputation, and loss of function [3]. The recommendations for treatment should take into account fracture characteristics such as comminution and the amount of soft tissue injury. Other important considerations in the initial assessment and treatment of open hand fractures that should also be taken into account include the degree of contamination and the adequacy of washout and debridement achieved in the emergency department (ED) [3, 4].

The time to surgery and its effect on the occurrence of infection has been controversial in the literature [2]. Studies evaluating the treatment of open fractures have found that the 6-h rule may be critical in fractures such as tibial fractures [5]. However, there has been scant clinical evidence to support this rule, especially in open hand fractures. Many studies support treating these injuries surgically within 24 h, whereas the administration of intravenous antibiotics in the ED seems to be critical in preventing the development of infection in open fractures in general and in the hand specifically [2, 6–8].

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Current guidelines do not differentiate between open fractures in large long bones such as the tibia, and between open hand fractures. They fail to address the unique factors and qualities of open hand fractures, which may play a role in the altered risk of infection. For example, because of the ability to provide adequate anesthesia in the emergency room, it is often possible to perform a thorough washout and debridement of the wounds, as well as to achieve temporary stability. Furthermore, open hand fractures are often initially ignored in multi-trauma patients, who may have more emergent medical conditions or in patients from remote rural locations [2, 9, 10].

We evaluated open hand fractures treated in our emergency room with intravenous antibiotics and washout under local anesthesia. The purpose of this study was to retrospectively evaluate the relationship between the amount of wound contamination, quality of washout and debridement achieved in the emergency room, and the development of infection. We hypothesized that the use of intravenous antibiotics and thorough washout/debridement in the emergency room can effectively reduce the occurrence of infection.

Materials and methods

All consecutive patients treated for open fractures of the hands in our emergency department between the years 2013 and 2016 were eligible for the study. Patients with open hand fractures treated by an orthopedic surgery resident in the emergency room were included in the study. Institutional review board approval was obtained prior to study commencement. Patients, who were not initially treated in the ED for the open fracture, were excluded from the study. Sixty-eight open fractures in 61 patients met the inclusion criteria.

All patients were treated according to standard of care by the orthopedic resident on call in the ED using an established protocol that included irrigation with copious amounts of sterile normal saline (until the wound looked clean). The wounds were irrigated using a 20-cm^3 syringe with normal saline. The guidelines were to irrigate the wound in the emergency department until the wound looked clean and then document the amount of saline used to obtain the grossly clean wound. Use of the syringe allowed for accurate measurement of the amount of fluid used. All patients received prophylactic intravenous (IV) antibiotics with 1 g of Cefamezin when the patient was not allergic to it, clindamycin when there was a known allergy. The order for antibiotic administration was given immediately upon arrival and evaluation in the emergency room. However, the interval between the injury and arrival varied between patients and unfortunately was not well documented in most instances. This treatment was then followed by oral antibiotic therapy to complete 2 weeks. The patients were treated for 2 weeks of antibiotics per protocol to prevent the occurrence of osteomyelitis. This policy was not based on the literature since we could not find clear guidelines for open hand fractures beyond the administration of IV antibiotics in the ED. Fixation was performed in the operating room as necessary.

Patients were seen in clinic by the treating surgeon 1 week following hospital or ED release and then every 2 weeks for a period of up to 3 months following the injury. The treating surgeon diagnosed infection according to signs and symptoms that included changes such as local increase in swelling, temperature, color change, increase in pain, loss of function or general signs, and symptoms of infection such as fever and malaise.

Contamination was documented by the treating resident using a scale of 1–3:

Grade 1 was defined as a clean wound such as a knife wound.
Grade 2 was dirty but can be cleaned easily.
Grade 3 was dirty—including wounds contaminated with organic material such as grass, substances that hard to clean such as oil and paint.

The amount of normal saline needed to yield a "clean" looking wound according to the irrigating/debriding surgeon was recorded in milliliters.

Demographic information was recorded including age, gender, hand dominance, smoking status, background disease (diabetes and hypertension), side of the injured hand, articular involvement, and the finger involved. Injury localization was documented as carpals, metacarpals, and proximal, middle, and distal phalanges. Hospitalization and follow-up period were recorded.

Statistical analysis

All the data analysis was carried out using SPSS, version 23. Pearson coefficient, Chi-square, and Fisher exact tests were used in order to evaluate associations between infection and other categorical variables. Continuous variables were analyzed using the Mann–Whitney U test. Level of significance was set as 5% (P value <0.005). For analysis, when a patient had more than one finger involved, one of the fractures was randomly chosen for the analysis.

Results

Sixty-one patients with 68 open fractures were included in our study. The mean age was 43 (21) years. There were 10 women and 51 men. Patient demographics are described in

Table 1 Patient demographics and the relationship to the development of infection

	N	*P* value
Age (SD)	43 (21)	0.65
Male (%)	83.6	0.63
Background disease (%)	12 (19.6)	0.67
Smoking (% smokers)	26 (42.6)	0.28
Right hand dominant (%)	32 (52.4)	0.76
Dominant = injured (%)	32 (52.4)	0.76

Age is described in years. No association was found between demographic variables and the development of infection

Table 2 Fracture characteristic and relationship to the development of infection

	N (%)	*P* value
Articular involvement (%)	12 (33.3)	0.36
Crush injury (%)	36 (66.7)	0.73
"Dirty" environment	43 (88.9)	0.26
Distal phalanx involved	46 (77.8)	0.42
Finger involved	61 (100%)	0.97
Index finger fracture	19 (33.3)	0.79
Middle finger fracture	10 (16.4)	0.78
Ring finger fracture	10 (16.4)	0.76
Little finger fracture	3 (4.9)	*
Thumb fracture	12 (19.7)	0.58
Multiple fingers	7 (11.5)	*

"Dirty" environment is per history. No associations were found between fracture characteristics and the development of infection

* Sample size was too small to evaluate the influence of this parameter

Table 1. We had follow-up information on all of the patients in the study.

There was an even distribution of the hand involved (dominant/non-dominant), and the index finger was involved most often. The most common location of fracture was the distal phalanx. Fracture characteristics are described in Tables 2 and 3.

Contamination was present in 43 patients (70.5%). A grossly contaminated wound (unable to clean) was observed in one patient. This patient was admitted and taken to surgery for debridement 48 h following the injury. He developed an infection despite the treatment. In 43 patients (70.5%), washout of 1000 ml or more was necessary to achieve a grossly clean wound. There was a significant relationship between the degree of contamination and the amount of fluid used for irrigation. Patients who were deemed to have more contaminated wounds received copious amounts of irrigation ($P = 0.000$).

In the ED, all patients were treated with intravenous antibiotics. Forty-eight patients (78%) received 1 g of Cefamezin, ten patients (16%) received 1 g of Augmentin (amoxicillin with clavulanic acid), and one patient received 1 g of Cefuroxime. Additional oral antibiotics were administered in 59 patients (96.7%). Although we could not estimate the exact time from the moment injury to patient's arrival to the ED, the majority of our patients (59) came directly following the injury, while two subjects were sent to the ED following a visit to a local ambulatory clinic.

The overall infection rate was 14.8% (nine patients). The amount of fluid needed for washout in the ED was significantly related to occurrence of infection ($P = 0.047$). The type of the oral antibiotic was significantly related to the occurrence of infection ($P = 0.039$). The amount of wound contamination was not significantly related to infection occurrence ($P = 0.259$). No significant relationship was found between crush level, finger involved, hand dominance, articular fracture, smoking status, comorbidities such as diabetes, and the occurrence of infection (Tables 1, 2, 3). The type of treatment used for fixation was not significantly associated with infection.

Forty-six patients (75%) were hospitalized. Days in hospital were an average of 1.9 days, and the longest hospitalization was five days with most of the finger fractures treated in the emergency department alone. No significant relationship was found between hospitalization and infection.

Eleven patients (18%) were taken to the operating room to treat their hand injury. Nine of these had surgery during the initial hospitalization or directly from the ED, and two had surgery performed later. One had surgery 2 weeks post-injury, and one was hospitalized a month following the injury. Of those patients treated during the initial hospitalization, the mean time to surgery from the moment of arrival to the ED was 31.4 h (2–85 h).

Table 3 Fracture location and association with infection

	Metacarpal	Proximal phalanx	Middle phalanx	Distal phalanx	Total
N	9	2	4	46	61
(%)	14.8	3.2	6.6	75.4	100
P value	0.98	*	*	0.61	0.42

There was no association between fracture location on the finger and the occurrence of infection

* Sample size was too small to evaluate the influence of this parameter

All but one of the infections was soft tissue infections treated with oral antibiotics in the community. Only one patient was hospitalized and diagnosed with osteomyelitis in the distal phalanx of her right ring finger. She was treated with IV antibiotics and surgical debridement.

Discussion

Open fractures in the hand and fingers are common. Despite established guidelines for the treatment of open fractures in general, the standards for the treatment of open fractures in the hand have not been well established. Identifying significant factors in the development of infection in the presence of these fractures, and taking into account the ability to achieve substantial washout and debridement in the ED may enable us to provide recommendations specific to open hand fractures. This may be especially beneficial to a busy trauma center where priorities for operating room time and resources in general are critical to providing efficient and optimal patient care.

A recent study found that time to surgery was not significant in predicting infection, while the administration of intravenous antibiotics, in the emergency room, is a major factor in decreasing infection rates in open hand fractures [6]. Other studies have claimed that emergent washout is equivalent to IV antibiotics [11]. These studies suggest that thorough washout of open wounds and meticulous wound care can effectively reduce the contamination causing deep infection, despite significant delays to initial operative treatment. Furthermore, Crowley et al. [12] argued that the use of antibiotics and the adequacy of the irrigation and debridement may be most important as a predictor of infection in cases of severe contamination.

In light of these results, all patients received intravenous antibiotics as part of standard of care. These were administered according to an established protocol. All patients in the study were to be treated with prophylactic Cefamezin 1 g intravenously, in the emergency department. However, for unclear reasons, not all patients were treated accordingly. When we compared between types of oral antibiotic (Augmentin to Cefamezin), we found a significant difference in infection rate between the two antibiotics ($P = 0.039$) with infections occurring more frequently after treatment with Augmentin than after Cefamezin which was the oral antibiotic prescribed most often (78%) by the orthopedic team. These patients had a 10.4% infection rate. Since Staphylococcus Aureus is the most common organism isolated in open hand fractures [3, 13], and considered as the most likely cause of infection, administration of a first-generation cephalosporin (e.g., Cefamezin) is likely more effective in patients with open fractures [14].

Recently, Glueck et al. [14] studied open fractures of the distal radius. They found no relationship between infection and time to initial irrigation and debridement, method of fixation, Gustillo and Anderson type, or Swanson type. They did show a correlation between initial contamination and subsequent infection, emphasizing contamination as a predictor of infection. Other studies have claimed that initial wound contamination was the most important predictor of infection [3]. In order to try and diminish bacterial load, irrigation with saline has been advocated shown to remove debris, lessen bacterial contamination, and decrease the incidence of wound infection rates [15]. Patzakis and Wilkins were able to show that delay to irrigation and debridement is only a factor in cases where time to antibiotic therapy was delayed [16].

This study did not find an association between contamination and infection; however, we did find a significant relationship between the amount of fluid necessary to achieve a grossly clean wound and the occurrence of infection ($P = 0.047$). Since there was a significant relationship between contamination and the amount of fluid used for irrigation stemming from our guidelines for treatment, the amount of fluid used for washout probably more accurately reflects contamination level. It is therefore reasonable to say that contamination was compensated for with the amount of fluid used for irrigation and that this probably masked any relationship that may have existed between initial wound contamination and the occurrence of infection as well as addressing the wound appropriately thus removing its effect on the development of infection.

Our infection rate was slightly higher than some described in the literature but not significantly different from most studies [14]. This may be due to different factors influencing the occurrence of infection such as the antibiotic type, and irrigation techniques and pressures [17]. Also, though we did not find a relationship between background diseases (including diabetes) and infection in our population, our prevalence of diabetes of 8.2% was slightly higher when compared with the 7.8% national average [18].

In summary, this study suggests that most open fractures in the hand can be treated appropriately in the ED. This is due to the ability to provide adequate anesthesia to perform a thorough washout and debridement. The treatment protocol should include intravenous antibiotic treatment upon arrival with use of Cefamezin as the preferred medication, as well as thorough washout and debridement, using as much fluid as needed to obtain a grossly clean wound. These guidelines have the ability to free operating room time for other more urgent cases especially in busy, high-volume trauma centers.

Compliance with ethical standards

Conflict of interest The authors have no conflicts to disclose.

Human and animal rights All human and animal studies have been approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Informed consent The patients were treated according to standard of care and did not sign an informed consent for the study.

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