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Hand Surgery & Rehabilitation
Hand Surgery and Rehabilitation 35 (2016) 266–270

Original article

# Contaminated wounds: Effectiveness of debridement for reducing bacterial load

## *Les plaies contaminées : efficacité du parage pour réduire l'inoculum bactérien*

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Received 22 December 2015; received in revised form 11 February 2016; accepted 26 June 2016
Available online 15 July 2016

**Abstract**

Surgical management of contaminated hand wounds may seem anecdotal, but such injuries actually account for an appreciable amount of the activity in emergency hand centers, and recommendations put forward by scientific societies differ. Dealing effectively with this public health issue calls for clarifying the usefulness of the various available treatments. Our study's objective was to determine the effectiveness of surgical debridement. In this prospective study, 92 patients with contaminated hand wounds underwent surgical debridement. Selection criteria included the length of time between injury and treatment, and the mechanism of injury. Patients with infected wounds, those treated by antibiotics, who were immunosuppressed or had osteoarthritis were excluded. Skin samples were collected both before and after debridement. In 62% of cases, the wounds were contaminated before debridement. Following the procedure, 87% of the bacterial smears were negative. The comparison between debridement and smear results was statistically significant (Student's $t$ test, $P < 0.001$). Surgical debridement, with appropriate irrigation, can effectively eradicate bacterial flora due to contamination.


*Keywords:* Surgical debridement; Hand; Wounds; Bites; Contaminated

**Résumé**

La prise en charge des plaies contaminées en chirurgie de la main peut paraître anecdotique, toutefois ces plaies représentent une partie non négligeable de l'activité des centres SOS mains. Devant cet enjeu de santé publique, et les recommandations divergentes proposées par les sociétés savantes, il convient de préciser l'utilité des traitements proposés. Notre objectif était de déterminer l'efficacité du parage chirurgical. Une série prospective de 92 patients présentant des plaies contaminées de la main ont été pris en charge pour réalisation d'un parage chirurgical. Ils étaient inclus selon la durée d'évolution de cette plaie ou le mécanisme vulnérant. Les plaies infectées, traitées par antibiotiques, les patients immunodéprimés et les lésions ostéo-articulaires étaient exclus. Des prélèvements bactériologiques avant et après le geste de parage étaient réalisés. Les plaies étaient contaminées avant la réalisation du parage dans 62 % des cas. Après parage, 87 % des prélèvements étaient négatifs. Une corrélation était observée entre le geste de parage et les résultats des prélèvements ($t$ Student ; $p < 0{,}001$). Une négativation statistiquement significative des prélèvements bactériologiques est observée après la réalisation du parage. Les gestes de parage, de rinçage, et de détersion mécanique des plaies durant l'acte opératoire permettent d'éradiquer la flore bactérienne due à la contamination. Le parage chirurgical semble efficace pour obtenir une négativation des prélèvements bactériologiques.


*Mots clés :* Parage chirurgical ; Main ; Plaies ; Morsures ; Contaminées

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http://dx.doi.org/10.1016/j.hansur.2016.06.001
2468-1229/

## 1. Introduction

In emergency hand centers, wounds are the most common reason for consultation [1]. However, two distinct sub-sets need to be separated, since managing infected wounds calls for a different protocol than managing clean wounds. At the same time, this dichotomy is not always clear in a busy emergency department. In fact, it is necessary to consider a third – transitional – category corresponding to contaminated, potentially infected wounds such as those from animal bites or those left untreated (or ''neglected'') for over 72 hours. In these cases, the clinical appearance of the injury does not allow the practitioner to determine whether the wound is clean. But given the risk of infection and the potentially risky individual clinical contexts, debridement must be nonetheless performed rapidly.

In routine emergency hand center practice, all wounds are systematically examined. Two approaches can be used with unclean wounds. In the absence of inflammatory signs [2,3], these wounds can be considered as not infected and treated by debridement without antibiotic therapy. On the other hand, prophylactic antibiotics can be systematically prescribed during the period immediately following surgical debridement [4].

Our main objective was to determine the effectiveness of debridement in achieving sterility of the surgical site. Secondarily, we sought to determine the impact of the mechanism of injury, as well as the nature of the bacterial flora as a function of the origin of the wound.

## 2. Materials and methods

This prospective, observational, single-center study was carried out between October 15, 2014, and July 31, 2015. Patient selection was based on clinical assessment upon arrival in the emergency department and included only patients whose wounds were deemed to be contaminated.

A wound is recognized as being contaminated when caused by an animal bite or when neglected for a minimum of 72 hours. Criteria for exclusion were wounds that were either clean (wounds not resulting from an animal bite or that had occurred less than 24 hours previously) or those with clinical signs of infection (redness, warmth, pain, swelling, with or without discharge). Further exclusion criteria were the existence of one or more comorbidities (diabetes, alcoholism, immunosuppression), prior systemic or local antibiotic treatment, as well as perioperative evidence of osteoarthritis or flexor tendon sheath injury.

Surgery was performed under regional anesthesia, with precautionary asepsis carried out according to current recommendations [5] and exsanguination of the limb. The procedure began by collecting a bacteriological sample according to Levine et al. [6], deep within the wound, labelled as the ''pre-cleaning smear''. This swab culture and smear technique, carried out by applying pressure to 1 $cm^2$ of tissue for 1 minute, allowed us to identify both aerobic and anaerobic bacteria (Portagem® Amies Agar, Biomérieux, Marcy-L'étoile, France). Systematic debridement was then performed to remove the entry point. This was followed by excision of devitalized tissue, extraction of any foreign bodies and full examination of the wound. Finally, the wound was irrigated with copious saline under pressure, before collecting a second bacteriological sample from the same site in the same manner (the ''post-cleaning smear''). The wound was closed using single-layer simple interrupted stitches with non-absorbable suture. Prophylactic perioperative intravenous antibiotics were administered systematically: 2 grams of amoxicillin and clavulanic acid if the patient had no allergy to penicillin. In the presence of such sensitivity [7], an injection of 600 mg of clindamycin was used in neglected wounds and 200 mg of doxycycline for bites. The first dose followed tourniquet exsufflation.

Postoperative treatment consisted of local wound care accompanied by 48 hours of prophylactic antibiotics. Amoxicillin associated with clavulanic acid was prescribed at 1 gram 3 times a day; in patients with penicillin allergy, 600 mg of clindamycin three times a day or a single daily dose of 200 mg of doxycycline was given. Patients returned for a follow-up visit 10 days post-operatively.

Our main endpoints were preoperative and postoperative microbiology results. Secondary endpoints were these same results as a function of the mechanism of injury and the nature of the bacterial flora relative to the wound's origin. A Student's $t$ test ($\alpha = 0.05$) was used to perform comparisons.

## 3. Results

### 3.1. Demographic data

Ninety-two patients were included (Table 1); the majority were men and their average age was 47 years. Two types of wounds were identified: neglected (untreated for over 72 hours, $n = 51$) and bites ($n = 41$); of the latter, 21 were cat bites and 20 were dog bites. Wounds were located in an area spanning from the wrist to the fingertips.

Table 1
Study population.

| | ($n = 92$) |
|---|---|
| *Sex ratio (M/W)* | 5/4 |
| *Mean age (years)* | 47.01 ± 17.03 |
| *Cause of the wound* | |
| Dog bite | 20 |
| Cat bite | 21 |
| Neglected wounds | 51 |
| *Location* | |
| Wrist | 5 |
| Hand | 35 |
| F1 | 12 |
| F2 | 18 |
| F3 | 9 |
| F4 | 9 |
| F5 | 4 |

M: men; W: women; F: finger.

### 3.2. Overall results

Before debridement, 62% of skin smears were contaminated. Bacteriological clearance was observed in 46% of cases following surgical debridement (Table 2). Thirteen bacterial species were identified, with a predominance of *Staphylococcus aureus* ($n = 15$) and *Pasteurella multocida* ($n = 11$, Table 3). All outcomes were favorable at the 10-day follow-up.

### 3.3. Neglected wounds

Before debridement, 55% of wounds were contaminated, compared to 4% following surgery (Table 2). Nine bacterial species were identified, with a predominance of Staphylococcus aureus ($n = 9$, Table 3).

### 3.4. Cat bites

Seventy-one percent of smears were contaminated before surgery; all were negative at the end of the procedure (Table 2). *Pasteurella multocida* was the most commonly found bacterium ($n = 11$), with five other species also being identified (Table 3).

### 3.5. Dog bites

Pre-cleaning smears were positive in 70% of cases. Following debridement, smears were positive in 45% of cases (Table 2). *Pasteurella canis* ($n = 4$) and *Staphylococcus aureus* ($n = 5$) were the most commonly found bacterial species. Six other bacteria were also identified (Table 3).

### 3.6. Statistical analyses

A Student's *t* test comparing contamination before and after cleaning showed a statistically significant larger proportion ($P < 0.001$) of sterile smears following the cleaning procedure for all wounds in the entire patient series (Table 2). The same result was found in all sub-categories: neglected wounds ($P < 0.001$), cat bites ($P < 0.001$) and dog bites ($P < 0.02$, Table 2).

Table 2
Smear results.

| | Smear positive *n* (%) | Smear negative *n* (%) | *P* value |
|---|---|---|---|
| *Entire population* | | | |
| Before debridement | 57 (62%) | 35 (38%) | < 0.001 |
| After debridement | 11 (12%) | 81 (88%) | |
| *Neglected wound* | | | |
| Before debridement | 28 (55%) | 23 (45%) | < 0.001 |
| After debridement | 2 (4%) | | 49 (96%) |
| *Cat bite* | | | |
| Before debridement | 15 (71%) | 6 (29%) | < 0.001 |
| After debridement | 0 | 21 (100%) | |
| *Dog bite* | | | |
| Before debridement | 14 (70%) | 6 (30%) | 0.02 |
| After debridement | 9 (45%) | 11 (55%) | |

Table 3
Bacterial flora present in wounds.

| | Pre-cleaning ($n = 57$) | After-cleaning ($n = 11$) |
|---|---|---|
| *All wounds* | | |
| *Enterobacter cloacae* | 2 | 0 |
| *Escherichia coli* | 3 | 0 |
| *Klebsiella oxytoca* | 1 | 0 |
| *Mannheimia haemolytica* | 1 | 1 |
| *Pasteurella canis* | 4 | 2 |
| *Pasteurella multocida* | 11 | 0 |
| *Prevotella oralis* | 1 | 0 |
| *Propionibacterium acnes* | 4 | 1 |
| *Staphylococcus aureus* | 15 | 4 |
| *Staphylococcus epidermidis* | 6 | 1 |
| *Staphylococcus warneri* | 4 | 1 |
| *Streptococcus agalactiae* | 1 | 0 |
| *Streptococcus oralis* | 4 | 1 |
| *Neglected wound* | | |
| *Enterobacter cloacae* | 2 | 0 |
| *Escherichia coli* | 3 | 0 |
| *Klebsiella oxytoca* | 1 | 0 |
| *Propionibacterium acnes* | 4 | 1 |
| *Staphylococcus aureus* | 9 | 1 |
| *Staphylococcus epidermidis* | 3 | 0 |
| *Staphylococcus warneri* | 2 | 0 |
| *Streptococcus agalactiae* | 1 | 0 |
| *Streptococcus oralis* | 3 | 0 |
| *Cat bite* | | |
| *Pasteurella multocida* | 11 | 0 |
| *Prevotella oralis* | 1 | 0 |
| *Staphylococcus aureus* | 1 | 0 |
| *Staphylococcus epidermidis* | 1 | 0 |
| *Staphylococcus warneri* | 1 | 0 |
| *Dog bite* | | |
| *Mannheimia haemolytica* | 1 | 1 |
| *Pasteurella canis* | 4 | 2 |
| *Staphylococcus aureus* | 5 | 3 |
| *Staphylococcus epidermidis* | 2 | 1 |
| *Staphylococcus warneri* | 1 | 1 |
| *Streptococcus oralis* | 1 | 1 |

## 4. Discussion

Wounds are the most common reason for people seeking out emergency hand care in France, accounting for nearly 600,000 cases per year [1]; animal bites make up a fifth of this total [8]. In the United States, where animal bites are tallied yearly, they represent 1% to 2% of all emergency room activity [9–12]. Given the stakes that one might project for France, the question of best management practices needs to be raised, particularly the effectiveness of surgical debridement and the usefulness of antibiotics. The latter point will be address in a future study by our group.

Our study found a higher proportion of animal bites than that reported in the literature. This may be explained by the timing of our study: particularly hot weather in France during the summer of 2015 [13] increased aggressive behavior in dogs and cats in response to weather-related stress [14].

Nearly 60% of all wounds in our series were contaminated before debridement, particularly, and logically, those resulting from bites. Without treatment, all wounds will evolve towards an infectious state. Following surgical management, bacteriological clearance was achieved in 50% of the initially contaminated smears. Surgical debridement allowed us to eliminate the bacterial load in most cases, with systematically statistically significant before-and-after results. For the 11 patients whose smear remained positive immediately following debridement, the bacterial load was nonetheless reduced, and outcome was favorable, as confirmed by the absence of clinical signs of infection at follow-up, 10 days post-operatively.

Dog bites seem to carry the highest risk of evolving towards infection, as evidenced by the persistence of bacterial load after debridement in nearly half of our cases. This phenomenon is due to the large surface area injured by this type of bite, to the degree of damage caused by the force of the bite itself and to resulting tissue lacerations. Consequently, debridement cannot be as thorough as it is for cat bites, in addition to the problems of wider-scale skin coverage. In cat bites, debridement makes it possible to perform *en-bloc* excision of the entry point. Nevertheless, unless surgery can be performed quickly, cat bites evolve more rapidly towards infection. Their characteristic deep and narrow entry point not only makes effective local treatment difficult for patients, but also strongly concentrates the bacterial inoculum [15,16].

In this series, 40% of preoperative smears were negative. While this data seems surprising, it can be explained in three ways. Firstly, the inclusion criteria were based on clinical elements, whereas contamination was determined by microbiological analysis. Secondly, the smear itself might have been a source of error due to technical issues or to a lack of sensitivity. The third possibility is simply that the wound is not contaminated.

The lower proportion of contaminated wounds in the neglected group reflects the mechanism of injury, as sources other than an animal's mouth harbor fewer bacteria. Contamination of neglected wounds occurs in two distinct manners: either directly from the initial injury, or during the time elapsed before treatment through exposure to a contaminated environment. These two situations result in a wide bacterial flora, thus explaining the large number of bacterial species identified – 13 – in our series. Nevertheless, *Staphylococcus aureus* was still responsible for half of the contaminations, which is a strong argument for the role of an unclean environment. The other prevalent species was *Pasteurella multocida*, unavoidable in cat bites. In the dog bites in our study, no one bacterium predominated.

One limitation of our study relates to the method of collecting smears, i.e., harvesting a single swab before and after wound cleaning. Nevertheless, two elements are relevant in managing contaminated wounds to the hand. On the one hand, the quantity of tissue that can be excised for bacteriological analysis is very limited, especially in the absence of infection, or where there is little devitalized tissue. On the other hand, Levine et al.'s [6] swab culture and smear method significantly lowers the risk of a false negative. Several studies have validated this technique [17,18] and have made it possible to obtain results similar to those obtained with tissue samples [19].

Surgical debridement of contaminated wounds appears sufficient to control the bacterial load in such lesions. Antibiotics could thus be limited to a single prophylactic perioperative dose [20]. Our results reflect the spirit of the SPLIF (French Infectious Diseases Society) recommendations, which calls for abstaining from prescribing local or systemic antibiotics if there are no local clinical signs of infection [16]. Nevertheless, this same body, along with various authors [9,13,16] recommends antibiotic therapy in contaminated wounds according to the degree of contamination. In a similar vein, the SFAR (French Society of Anesthesia & Intensive Care Medicine) differentiates between a first group of ''clean and clean-contaminated wounds'' and a second group of ''contaminated and dirty wounds'' [20]. This differentiation makes it possible to propose prophylactic antibiotics for the first group and antibiotic therapy for the second. However, to us, this separation into clean-contaminated and contaminated wounds once again appears to be too theoretical. The only real practical differentiation criterion is the absence or presence of clinical signs of infection. The effectiveness of surgical debridement of contaminated wounds, as supported by the results of our bacteriological analyses, leads us to question the need for antibiotic therapy. Intravenously administered perioperative prophylactic antibiotics could well suffice, making it possible to categorize such wounds, after surgical debridement, as ''clean-contaminated'', following SPILF and SFAR recommendations.

## 5. Conclusion

Management of contaminated wounds must be unquestionably based on surgical debridement, the only sure way to rapidly and reliably reduce the bacterial load. Our encouraging results suggest the next step is to explore the usefulness of adjuvant antibiotic therapy.

## Disclosure of interest

The authors declare that they have no competing interest.

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