



## A descriptive study on the surgery and the microbiology of Gustilo type III fractures in an university hospital in Switzerland

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**Objective :** To describe the epidemiology, the surgical treatment, the microbiology, the antibiotic prophylaxis and the outcome of patients with the most severe type of open fractures.

**Methods :** Retrospective chart reviews of patients with Gustilo type III open fracture admitted to an university hospital in Switzerland between January 2007 and December 2011. The patient's and fracture's characteristics, surgery, antibiotic prophylaxis, and microbiology findings at the initial and at the revision surgery were described.

**Results :** Thirty patients were included (83% male, mean age 41 years). More than half of the patients had polytrauma. In all patients, debridement and stabilization surgery (70% using external fixation) were performed at admission. Soft tissue reconstruction was performed in 87% and in 23% immediate bone graft was performed. Antibiotic prophylaxis were given in all patients for a median duration of 9 days (60% received amoxicillin/clavulanic acid). Positive bacterial culture was found in 53% of the patients at initial surgery and in 88% at revision surgery. At initial and revision surgery, 47% and 88% of the pathogens were amoxicillin/clavulanic acid-resistant. Treatment outcome was favorable in 24 of 30 patients (80%) and in six cases (20%) an amputation had to be performed. None of the patients had chronic bone infection.

**Conclusions :** Positive cultures were found often in open fractures. Amoxicillin/clavulanic acid which is often mentioned in many guidelines as prophylaxis in open fractures does not cover the most common isolated organisms. The combination of surgery and an-

**tibiotic prophylaxis leads to good outcome in Gustilo type III fracture.**

**Keywords :** trauma ; open fracture ; infection ; microbiology ; antibiotic prophylaxis.

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### INTRODUCTION

Fractures are major public health concern. Every year, approximately one out of every 120 people under the age of 65 years has a fracture (2). Among

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all fractures, 3% are considered as open (4). Open fractures are usually resulting from high-energy trauma but can also be caused by fall (5). The most commonly used system to classify open fractures is the Gustilo classification (11). This classification is based on mechanism of injury, the degree of soft tissue damage, the configuration of the fracture, and the level of contamination.

In open fracture, the skin and soft tissues are disrupted and there is communication between bone and outside environment (15). Therefore, the potential for contamination is high. It can even be assumed that in open fracture, surgery will take place in contaminated area. Therefore, short-term empirical antibiotic prophylaxis should be given before surgery (12,21). The most severe fractures are categorized into type III injuries (10). Arguably, this type of fracture has the highest risk of infections among all type of fractures.

To the best of our knowledge, no study on the epidemiology, the surgical treatment, antibiotic prophylaxis and the outcome has been performed specifically in Gustilo type III fractures. The aim of this study is to describe the epidemiology, the surgery, the microorganisms, antibiotic prophylaxis, and outcome in a population with Gustilo type III open fractures.

## PATIENTS AND METHODS

### Setting and study population

The study was performed in Lausanne University Hospital, Switzerland. The hospital is one of five university hospitals in Switzerland. It has around 1400 beds and it serves as a trauma center. The study was approved by the institutional review board.

We reviewed the charts of patients with Gustilo type III open fractures of the lower limb admitted between January 2007 and December 2011. Gustilo type III fractures were defined as fractures with extensive soft-tissue lesions and divided into three subtypes (11). Type IIIA is characterized by high-energy trauma, extensive soft-tissue damage, and substantial contamination with adequate wound coverage. Type IIIB is similar to type IIIA, except that wound coverage is inadequate with exposed bone at the end of debridement. Type IIIC is every type of open fracture associated with arterial injury needing repair.

Demographic characteristics, clinical presentation, type of fracture, surgical, microbiology, antibiotic treatment and patient outcome were recorded using a standardized case-report form. We differentiated between fractures of the upper leg (femur) and the lower leg (tibia and fibula).

### Surgical treatment

Data on initial surgery were collected regarding debridement, stabilization type, type of soft tissue reconstruction, and whether bone graft was needed.

### Microbiological analysis

Deep wound swabs or tissue biopsies obtained at initial revision surgery were sent for aerobic and anaerobic cultures. Cultures were incubated at 37° C for 10 days. Isolated microorganisms were identified and their antimicrobial susceptibility was tested using standard microbiological techniques.

### Antibiotic prophylaxis

In our hospital, the most commonly used antibiotic prophylaxis in Gustilo type III fracture is amoxicillin/clavulanic acid, according to the available international guideline (21). Only in several cases, the choice of antibiotics is given at doctor's discretion. Changes to rational antibiotics were based on antimicrobial susceptibility tests.

### Outcome evaluation

Treatment outcome was analyzed by reviewing the medical charts, and by contacting patients or patient's general practitioners by phone. We collected the following data : number of operations, amputation, chronic bone infection and death attributed to complication of initial trauma or during clinical course suggesting. Favorable outcome was defined as favorable when no amputation and no chronic infection occurred. Chronic infection was defined as persisting infection longer than 3 months after cure of the previous episode.

### Statistical analysis

In this descriptive study, number and percentages were calculated. No further statistical analysis were performed.

Table I. — Demographics and characteristics of patients with type III open fracture of the lower leg

Patient characteristics	n = 30
Mean age (range), years	40.5 (17 to 67)
Sex, male (%)	25 (83.3%)
Hospital stay, median (range), days	46.5 (4 to 109)
Fracture type, n (%)	
IIIA	3 (10%)
IIIB	21 (70%)
IIIC	6 (20%)
Localization of fracture, n (%)	
Lower leg	27 (90%)
Upper leg	3 (10%)
Type of trauma, n (%)	
Monotrauma	14 (46.7)
Polytrauma	16 (53.3)
Velocity-induced trauma, n (%)	
High energy	24 (80%)
Low energy	6 (20%)
Mechanism of trauma, n (%)	
Accident	27 (90%)
Car/motorcycle	20 (74.1%)
Plane	1 (3.7%)
Work	6 (22.2%)
Fall	3 (10%)

## RESULTS

### Demographic and clinical characteristics

Thirty patients with type III open fractures were included (Table I) : 83% of them were males, mean age was 41 years (range : 17 to 67 years). The most common fracture was Gustilo type IIIB (n = 21, 70%), and in 90% (n = 27) the fracture was localized on the lower leg. In most cases (n = 24, 80%) the fracture was due to high-energy trauma. The most common cause was accident by car or motorcycle in 20 (70%) cases. More than the half of the patients (n = 16, 53%) had multiple trauma.

### Surgical treatment

All patients received immediate debridement and stabilization (Table II). The most common initial

Table II. — Initial surgical intervention

Initial surgical approach	n (%)
Debridement	30 (100%)
Stabilization	30 (100%)
Splint	2 (7%)
External fixation	21 (70%)
Internal fixation (nail, plate, other)	3 (10%)
Internal and external fixation	4 (13%)
Soft tissue reconstruction	26 (87%)
Skin graft (Thiersch)	7 (27%)
Local flap	4 (15%)
Local flap and skin graft (Thiersch)	10 (38%)
Free flap	2 (8%)
Free flap and skin graft (Thiersch)	3 (12%)
Bone graft	7 (23%)

stabilization was by using external fixation (n = 21, 70%). Other stabilization methods were : combination of external and internal fixation in four (13%), internal fixation in three (10%), and splints in two (7%) patients.

At initial surgery, 26 patients (87%) underwent soft tissue reconstruction during hospitalization and seven (23%) needed an immediate bone graft. The most common used soft tissue reconstruction was local flap and skin graft (Thiersch) in 10 (38%) patients, followed by skin graft only in seven (27%), local flap in four (15%), free flap and skin graft in three (12%), and free flap in two (8%) patients.

### Prophylaxis antibiotic

Prophylaxis antibiotic were given in all patients for an average duration of 8.5 days (range, 1 to 53 days). Eighteen patients (60%) received amoxicillin/clavulanic acid (Table IV). Initial antibiotic was changed in 19 patients (63%) and in 11 patients the antibiotic therapy was stopped.

### Microbiology

Cultures of deep tissue biopsies at the initial surgery were available from 19 patients (63%). In ten patients (53%) cultures were positive, in five patients more than one type of bacteria (polymicrobial) was found (Table III). The most common

Table III. — Microbiology results from deep tissue biopsy at initial surgery (before preemptive antibiotic treatment) and at revision surgery (median day 7, range 2 to 25 days after antibiotic treatment)

	At initial surgery		At revision surgery (median: 7 days, range 2 to 25 days after antibiotic treatment)	
Number of patients with available cultures	19 (63%)		25 (83%)	
Negative	9		3	
Positive	10 (53%)		22 (88%)	
Monomicrobial	5		5	
Polymicrobial	5 (50%)		17 (77%)	
Isolates*	n	Resistance to amoxicillin/clavulanic acid (%)	n	Resistance to amoxicillin/clavulanic acid (%)
<i>S. aureus</i>	1	0	0	0
CNS*	13	0	6	4 (67)
<i>Bacillus cereus</i>	7	7 (100)	10	10 (100)
Gram negative	8	7 (88)	32	30 (94)
Anaerobes <sup>†</sup>	1	0	2	0
Total	30	14 (47)	50	44 (88)

Abbreviation: CNS, coagulase negative staphylococci.

isolated pathogens were coagulase-negative staphylococci (n = 13, 43%) followed by Gram-negative bacteria in 8 (27%) isolates. Among the pathogens, 47% were resistant to amoxicillin/clavulanic acid.

The revision surgery took place after median of 7 days (range, 2 to 25 days). Deep tissue cultures from revision surgery were available from 25 patients (83%). Positive cultures were found in twenty-two patients (88%), 17 (77%) of them were polymicrobial (Table IV). The most common isolated organisms were gram-negative bacteria (n = 32, 64%). 88% of all isolated pathogens were amoxicillin/clavulanic acid resistance. In 3 patients no organism was cultured.

### Outcome

Median number of operation during hospitalization was 8 (range : 2 to 18). Treatment outcome was favorable in 24 of 30 patients (80%). In six cases (20%) an amputation had to be performed, after a median duration of 5.5 days (range : 1 to 420 days).

None of the patients suffered from chronic bone infection or deceased.

### DISCUSSION

This study is a descriptive study focuses only on the most severe type of open fracture, i.e. Gustilo type III. We confirm several demographic aspects of open fracture such as predominance of young male (5,7). Yet, as it can be expected, our patients are younger and had more involvement of vehicle accident than the studies that included all type of open fractures. For example, compared to an epidemiology study on all Gustilo types in Edinburgh, Scotland (5), our study population consists of more males (83 vs. 66%), younger (41 vs. 45 years), and had more involvement of vehicle accident (74 vs. 58%). The number of the patients in the present study might seem small. However, it might represent the epidemiology of the most severe type of open fracture in an university hospital of a high income country. A retrospective study performed in

Table IV. — Antibiotic therapy

Preemptive therapy	
Duration, median (range), days	8.5 (1 to 53)
Antibiotics, n (%)	
Amoxicillin/clavulanic acid	18 (60.0)
Quinolone	1 (3.3)
Cephalosporin	6 (20.0)
Piperacillin/tazobactam	2 (6.7)
Carbapenem	3 (10.0)
Change of preemptive antibiotic therapy	
Duration, median (range), days	21 (6 to 57)
Antibiotics, n (%)	
Amoxicillin/clavulanic acid	1 (3.3)
Quinolone	5 (16.7)
Cephalosporin	1 (3.3)
Piperacillin/tazobactam	5 (16.7)
Carbapenem	6 (20.0)
No antibiotics	11 (36.7)

another university hospital of a larger city in Switzerland documented an average of 13 patients with Gustilo type III fracture every year (vs. 6 patients per year in our study) (7).

The management of open fractures combines the principles : assessment of the patient, classification of the injury, antibiotic prophylaxis, wound management and fracture stabilization (8). All patients in our study were taken immediately to the operating room for initial irrigation, surgical debridement and fixation. Already in 1986, Godina showed that performing early soft tissue reconstruction reduce the infection rate (9). Interestingly, this policy seems to lose support in the more recent literature. Schenker and colleagues performed a systematic review and showed that there is no association between delayed debridement and higher infection rates (19). As it can be expected, the number of interventions in our study was higher than in another study (7) that included all type of open fracture (median of 8 vs. median of 2 interventions).

A strength of this study is that the culture was taken from deep tissue during the surgery in the majority of the patients. As comparison, in a larger study, only 29% intra-operative samples were collected at initial surgery (7). We found that 53% and 88% of fracture are contaminated at the time of

initial surgery and at the time of revision surgery, respectively. The high level of contamination is in line with the evidence from the literature (6,17). Arguably, the cultures taken after the first debridement and after the course of antibiotic prophylaxis might indicate the potential microorganisms that may cause infection in the future (7,18). It has been shown previously that a large majority of infections complicating grade III fractures are caused by pathogens presumably selected by the prophylactic antibiotic used (7).

In our study, all patients received antibiotic prophylaxis but the antibiotic prophylaxis did not fully cover the spectrum of microorganisms. In our hospital, the majority of antibiotic prophylaxis used is amoxicilline/clavulanic acid. There is a wide variety of antibiotic choices for prophylaxis in open fracture. Some suggest the use of second-generation cephalosporins alone (1,12). Some others suggest the combination of cephalosporins with aminoglycosides that cover Gram- negative bacteria (13). The combination of cephalosporins with quinolones has also been investigated (16). Covering anaerobic microorganisms has also been proposed (20). Yet, the number of anaerobes found in the culture, for example in this study is so low.

Regarding the duration of antibiotic prophylaxis, the patients in our study received various duration of antibiotics. In the literature, there is no consensus on how long antibiotic prophylaxis should be given. Some authors discourage the use of repetitive dose since it can increase the risk of resistance to antibiotics (12), while some others advocate continuation up to 72 hours after injuries (13). A study even used antibiotic prophylaxis until several weeks (14). A recent study showed that for grade III fractures, a one-day course of prophylactic antibiotics might be as effective as prolonged prophylaxis (7).

Despite that our antibiotic prophylaxis did not cover the whole microorganisms spectrum, the outcome of the patients in our study were favourable ; no chronic infections were found. There are two possible explanations. Firstly, appropriate surgery might be an important or even a predominant factor of favourable outcome in open fracture. Secondly, not all microorganisms in open fracture will cause infection. We can speculate that contamination

leads to infection in favourable milieu. For example, Gustilo type III open tibia fractures from combat (3) had much higher infection rate than Gustilo type III from non-combat trauma. The favourable outcome of the patients in our study, on the other hand, can be also explained by the multidisciplinary approach. Such an approach involves orthopedic surgeons and also plastic and vascular surgeons. It is also important to involve microbiologists and infectious disease specialists, regarding the antibiotic therapy (8). When initial surgical intervention is accompanied by correct antibiotic therapy, the outcome can be improved : the bony and soft tissue can be healed, and acute or chronic osteomyelitis can be prevented (8,12).

In conclusion, we showed that positive cultures are found often in open fractures, and amoxicillin/clavulanic acid as prophylaxis antibiotic does not cover the most common isolated organisms in open fractures. It seemed that the combination of surgery and prophylaxis antibiotic is needed to guarantee a favorable outcome in the most severe type of open fracture.

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