International Orthopaedics (SICOT) (2017) 41:1291–1294
DOI 10.1007/s00264-016-3382-1

ORIGINAL PAPER

Bone cultures from war-wounded civilians in the Middle East: a surgical prospective

Patrick Hérard[1] · **François Boillot**[1] · **Rasheed M. Fakhri**[2]

Received: 22 November 2016 / Accepted: 19 December 2016 / Published online: 18 January 2017

Abstract
Purpose Hidden infections in a reconstructive surgery program are frequently underestimated.
Methods A retrospective study was undertaken of 1,891 civilian war-wounded patients from Iraq, Syria, Yemen and Gaza treated in Amman from August 2006 to January 2016. One thousand three hundred and fifty-three underwent surgical interventions for previous bone injury and had systematic bone cultures.
Results Among patients (167) without any clinical, biological or radiological signs of infection, 46% demonstrated infection based on bone cultures. We conclude that bone culture should become a prerequisite for any reconstruction in such contexts.

Keywords Bone culture · War surgery · Bone reconstructive surgery

Introduction

Médecins Sans Frontières (MSF) began a civilian reconstructive war-wounded program in Amman in 2006. The project aimed to treat civilian Iraqi victims of violence and later expanded to include victims of violence in neighbouring countries, including Syria, Yemen and Gaza [1].

The project provides surgical reconstructive operations in the specialties of orthopaedic, plastic and maxillofacial surgery. From the first days of the project, MSF specialists in the fields of surgery and infectious disease were faced with high percentages of bone infections in those patients [2].

The majority of patients were referred to the project without a complete history of injury type, mechanism of injury, initial treatment and subsequent pre-referral surgical management. MSF decided as a protocol to obtain bone cultures from all patients who had a previous war-related injury regardless of their clinical presentation or the type of surgery [1].

In this study we describe the retrospective analysis of those bone cultures and lessons learned.

Patients and methods

We performed a retrospective analysis of bone-culture findings from August 2006 to January 2016. As described above, all patients with prior bone injury requiring further treatment in our project had bone and deep soft-tissue cultures from their site of injury during the first reconstructive surgery. We did not perform bone cultures in the context of non-infected, soft-tissue surgical sites. Likewise, patients who had previously undergone bone surgery in virgin tissue for non-penetrating trauma and those with no prior surgical intervention were excluded.

A standard procedure for obtaining an open bone culture was used [3, 4]. The results of swab cultures from sinus tract infections were excluded as tissues sampling were requested [5, 6]. The surgeons were asked to obtain three to five cultures from the bone and soft tissue in the area. The results of these cultures were registered in the WHONET software of lab management and the data were retrospectively analysed accordingly (http://www.who.int/drugresistance/whonetsoftware/en/). Prophylactic antibiotics were either not given before surgery or stopped at least two weeks before.

✉ Patrick Hérard
pherard@paris.msf.org

[1] Médecins Sans Frontières, Paris, France

[2] Médecins Sans Frontières, Amman, Jordan

Selection of the culture site was sometimes problematic and left to the surgeon's discretion. Straightforward areas for culture included sequestra, previous pin and screw sites, discoloured bony areas and suspicious-appearing soft tissue. More difficult decisions were encountered in areas where the bone appeared normal, or with minimum changes in colour, and those with no obvious abnormal tissue. Bone sequestra were sent as a whole segment to the lab, but larger fragments proved to be more challenging as extensive release of soft tissues could cause more damage [7].

Any positive bone culture was considered as a case of osteomyelitis, and after full debridement, the patient received six to 12 weeks of antibiotics according to MSF protocols. Exceptions to the treatment regimen included cases in which positive results were related to coagulase-negative *Staphylococcus* bacteria.

The surgery was divided into two major categories: debridement with external fixation in cases where clinical presentation suggested infection, and debridement of bone edges with placement of plates, nails or screws (cannulated or non-cannulated) where no clear clinical, biological or radiological signs of infection were evident.

Results

A total of 1,891 patients underwent orthopaedic surgery which were undertaken during the period from August 2006 to January 2016. Based on inclusion criteria, bone cultures were obtained from 1,353 patients.

We reviewed retrospectively the results of 5,578 individual cultures obtained from these 1,353 patients. Mean age of patients was 32 years with a predominance of males (86%).

The distribution of cultures according to type of surgery is detailed in Table 1.

The total number of cultures represents an average of 4.1 cultures for each surgical intervention, without a statistical difference demonstrated between the type of surgery and the number of cultures (P value = 0.76948).

The results of bone cultures, whether they were infected or not, according to the type of surgery are shown in Table 2.

Table 1 The distribution of patients and cultures according to type of surgical fixation

Type of fixation	Number of patients (%)	Number of cultures
Debridement/external fixation	991 (73%)	4,506
Nail	162 (12%)	516
Plate	164 (12%)	493
Screws	36 (3%)	63
Total	1,353 (100%)	5,578

Table 2 Occurrence of infection of bone cultures according to the type of surgery

Type of fixation	Infected (%)	Not infected (%)	Total (%)
Debridement/ external fixation	850 (86%)	141 (14%)	991(100%)
Nail	80 (49%)	82 (51%)	162(100%)
Plate	74 (45%)	90 (55%)	164(100%)
Screws	13 (36%)	23 (7%)	36(100%)
TOTAL	1,017 (75%)	336 (25%)	1,353(100%)

For the 167 patients with internal fixation (nails, plates and screws), 46% were infected and 54% non-infected.

The average number of cultures taken from the non-infected patients (2.5 cultures/patient) was less than the number of cultures taken from infected ones (mean 4.9 cultures/patient), with a strong statistical significance (t-test, 0.000).

The type of sample infected with respect to the type of surgery is shown in Table 3, and the types of bacteria and number of isolates are shown in Table 4.

Discussion

Bone infections constitute one of the worst possible complications in war injuries [8, 9]. MSF projects to treat victims of violence in the Middle East have faced the same challenges from their first days [1, 2]. These challenges were represented by a very high number of patients arriving at the projects already infected, a high percentage of antibiotic resistance (55%) [2] and, in the isolated bacteria, uncertainty about the causes of these infections and their histories. The need for lab accuracy in isolating these bacteria, as well as the development of specific protocols for surgical management and antibiotic treatments, have been additional operational challenges.

Bone and deep soft-tissue cultures represent the principal investigative assays and have the final word about the presence or not of bone infection [7]. There are few articles describing the surgical component of bone cultures in war-wounded. Most major articles are either linked to medical conditions [6] or the comparison with needle biopsies [5] and sinus tracts cultures [10, 11]. The peculiarity of our project is that we were doing bone cultures for all patients regardless of their initial clinical, radiological or biological presentations.

The bacteriology analyses of those cultures are described in Table 4 and show a predominance of *Staphylococcus aureus*, *Escherichia coli*, coagulase-negative *Staphylococcus* and *Pseudomonas aeruginosa*. Almost the same pattern of infection was found in other studies done in this project [2, 12].

The main surgical intervention was debridement and external fixation. This procedure is the usual management of such

Table 3 Infection of soft tissue or bone according to type of surgery

Type of fixation	Only soft tissue was positive (%)	Only bone was positive (%)	Both were positive (%)	Total (%)
Debridement/external fixation	137 (16%)	403 (47%)	310 (37%)	850 (100%)
Nail	12 (15%)	48 (60%)	20 (25%)	80 (100%)
Plate	8 (11%)	40 (54%)	26 (35%)	74 (100%)
Screws	8 (1%)	6 (46%)	6 (46%)	13 (100%)
TOTAL	158 (16%)	497 (49%)	362 (35%)	1,017 (100%)

injuries. At the same time, internal fixation by means of nails, plates or screws (cannulated or non-cannulated) were done in specific patients where we anticipated no infection. Nonetheless, 46% of those cases proved to be infected based on cultures.

This evidence made us fully confident about the importance of obtaining bone cultures, even in the absence of clinical, radiological and biochemical elements of infection, especially for cases scheduled for internal fixations. These findings also raise the alarm that there are many missed opportunities to discover hidden infections at the first stage of reconstructions.

Despite the clear protocol of having a minimum of three to five bone samples for each patient, the data showed that the number of cultures taken from non-infected patients was statistically significantly less than the average number of bone samples taken for infected patients, and even less than the minimum required by the protocol. We believe that the surgeons were more confident that there was no infection during internal fixation, seeing less visible suspicious tissues (soft or bone) requiring sampling during internal fixation. This finding could lead us to think that we might have minimised our hidden infection rate by decreasing the number of samples in internal fixations surgeries.

The bone samples showed more positive results in comparison to deep soft-tissue ones. Sixteen percent of positive cultures were only from deep soft tissues at the time they were negative from bone. The soft tissues at a non-union site can be a reservoir for bone infection, and it is important to include them in cultures. Forty-nine percent of positive cultures were from bone only and 35% were from both bone and soft tissue.

All cultures were performed during the first surgery. This procedure for patients with internal fixation were discussed from the beginning in 2006, balancing the risk/benefit ratio for infection. Our choice was to go ahead, taking the samples, fixing the bone in one surgery and treating with appropriate antibiotics if positive. We considered that the alternative of taking biopsies and thus converting what was a relatively quiescent wound or infection into a new open wound, followed by a second surgery a few days later, created more risks of reactivation of the infection.

The infection recurrence rates, as well as the surgical and functional outcomes in this project, were analysed in previous retrospective studies and demonstrated an infection recurrence rate of 7% in infected tibial non-union with better functional improvements for non-infected patients presented with more functional disabilities [1, 13].

In this study, the retrospective analysis of bone culture results gave us key messages; bone cultures are a prerequisite for bone reconstruction after war injuries, regardless patient clinical presentation. This becomes particularly accurate for

Table 4 Types of bacteria per infection site and number of isolates

Bacteria type	Infected external fixation		Infected nail		Infected plate		Infected screw		Total	
	(*n*)	%	*n*	%	*n*	%	*n*	%	*n*	%
Staphylococcus epidermidis	86	5.2%	6	5.9%	8	8.7%	0	0.0%	100	5.4%
Acinetobacter baumannii	36	2.2%	1	1.0%	1	1.1%	0	0.0%	38	2.0%
Escherichia coli	272	16.4%	20	19.8%	13	14.1%	3	16.7%	308	16.5%
Klebsiella pneumoniae	113	6.8%	3	3.0%	4	4.3%	0	0.0%	120	6.4%
Others	90	5.4%	3	3.0%	4	4.3%	1	5.6%	98	5.3%
Pseudomonas aeruginosa	213	12.9%	2	2.0%	8	8.7%	1	5.6%	224	12.0%
Proteus mirabilis	95	5.7%	3	3.0%	1	1.1%	0	0.0%	99	5.3%
Staphylococcus aureus	485	29.3%	28	27.7%	19	20.7%	8	44.4%	540	28.9%
Staphylococcus, coagulase negative	177	10.7%	32	31.7%	31	33.7%	3	16.7%	243	13.0%
Streptococcus viridans, alpha-hem.	88	5.3%	3	3.0%	3	3.3%	2	11.1%	96	5.1%
	1,655	100%	101	100%	92	100%	18	100%	1,866	100%

internal fixation surgeries. Sufficient samples should be taken even in the absence of a clinical suspicion for infection and soft-tissue cultures should not be forgotten.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Funding There is no funding source.

Studies with human participants or animals This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. Fakri RM, Al Ani AM, Rose AM, Alras MS, Daumas L, Baron E et al (2012) Reconstruction of nonunion tibial fractures in war-wounded Iraqi civilians, 2006–2008: better late than never. J Orthop Trauma 26(7):76–82
2. Murphy RA, Ronat J-B, Fakhri RM (2011) Multidrug-resistant chronic osteomyelitis complicating war injury in Iraqi civilians. J Trauma 71(1):252–254
3. Mader JT, Ortiz M, Calhoun JH (1996) Update on the diagnosis and management of osteomyelitis. Clin Podiatr Med Surg 13(4):701–724
4. Wilson ML, Winn W (2008) Laboratory diagnosis of bone, joint, soft-tissue, and skin infections. Med Microbiol 46(3):453-457
5. Mackowiak PA, Jones SR, Smith JW (1978) Diagnostic value of sinus-tract cultures in chronic osteomyelitis. JAMA 239(26):2772–2775
6. Senneville E, Melliez H, Beltrand E et al (2006) Culture of percutaneous bone biopsy specimens for diagnosis of diabetic foot osteomyelitis: concordance with ulcer swab cultures. Clin Infect Dis 42: 57–62
7. Ochsner PE, Bornes O et al (2014) Infections of the musculoskeletal system, basic principles, prevention, diagnosis and treatment. Heraeus Medical, Hanau, pp 84–85
8. Tong MJ (1972) Septic complications of war wounds. JAMA 219: 1044–1047
9. Yun HC, Murray CK, Roop SA, Hospenthal DR, Gourdine E, Dooley DP (2006) Bacteria recovered from patients admitted to a deployed U.S. military hospital in Baghdad, Iraq. Mil Med 171: 821–825
10. Howard CB, Einhorn M, Dagan R, Yagupski P, Porat S (1994) Fine needle bone biopsy to diagnose osteomyelitis. J Bone Joint Surg (Br) 76(2):311–314
11. Zuluaga AF, Galvis W, Jaimes F, Vesga O (2002) Lack of microbiological concordance between bone and non-bone specimens in chronic osteomyelitis: an observational study. BMC Infect Dis 2:8
12. Teicher CL, Ronat J-B, Fakhri RM, Basel M, Labar AS, Herard P, Murphy RA (2014) Antimicrobial drug–resistant bacteria isolated from Syrian war–injured patients, August 2011-March 2013. Emerg Infect Dis 20 (11):1949-1951
13. Teicher C, Foote NL, Al Ani AMK, Alras MS, Alqassab SI, Baron E, Ahmedd K, Herard P, Fakhri RM (2014) The short musculoskeletal functional assessment (SMFA) score amongst surgical patients with reconstructive lower limb injuries in war wounded civilians. Injury 45:1996–2001