Input of a Multi-Disciplinary Meeting in the Treatment of Osteoarticular Infections in French War Casualties

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ABSTRACT  Introduction: Extremity war-wounds present an elevated risk of infection and compromise reconstructive procedures. In a French military hospital, a multi-disciplinary meeting (MDM) was created to standardize the care given to soldiers with osteoarticular infection. The aim of this study was to evaluate the usefulness of MDM decisions. Methods: An observational case study was performed including the French wounded at war treated for an osteoarticular infection between 2004 and 2016. They were separated into two groups according to their time of management: before (group A) or after (group B) the MDM creation in September 2010. Various operative and bacteriological parameters were analyzed retrospectively. A questionnaire was created to evaluate healthcare professionals’ satisfaction toward the usefulness of the MDM on their practice. Results: During the study period, 38 patients were included: 19 in group A and 19 in group B. Initial tests found an infection with one pathogen in 15 patients, an infection with 2 pathogens in 11 patients, and an infection with 3 or more pathogens in 12 patients. Enterobacter cloacae was the most common pathogen. Pseudomonas aeruginosa and Escherichia coli were also frequent. The mean number of samples taken to conduct the bacteriological tests per operating session was significantly higher for group B than for group A. Twelve of the 14 questioned healthcare professionals believed the MDM was very useful in their patient management. Conclusion: The MDM seems to have had a beneficial impact on orthopedic surgeon practices. A significant increase of the number of samples taken was the most obvious sign that the French recommended practices for osteoarticular infections were followed since the creation of MDM.

INTRODUCTION

Extremity combat wounds are mostly related to high energy trauma. They are characterized by extensive bone and soft tissue attrition and are frequently associated with other life or sight-threatening injuries. With regards to open fractures, the risk of contamination of the wounds is very high (stage 3 or 4 of Altemeier’s classification). The infection of war wounds makes the definitive treatment more difficult, especially concerning reconstructive procedures and lessens functional outcome.

The primary surgical management is performed on the battlefield in level 2 or 3 medical treatment facilities (MTFs) with a systematic application of damage control orthopedic (DCO) procedures. Recommendations concerning prophylactic antibiotic treatment within a combat context stem from expert opinions. Antibiotics are ideally given 3 hours after the trauma and for a maximum period of 5 days. Amoxicillin–clavulanic acid is used in the French Army and associated with gentamicin in cases of Gustilo 3 open fractures or severe telluric contamination (mine injuries). Once DCO procedures are completed, the wounded are evacuated out of the combat zone for the definitive treatment. Most of the severely injured French soldiers are evacuated to the Percy military teaching hospital (level 4, MTF).

In September 2010, the orthopedic and trauma department of the Percy hospital modified the care support system of the injured soldiers with osteoarticular infections. Recommendations by the Health Ministry concerning the care of complex osteoarticular infections as well as recommendations by the French Superior Health Authority (SHA) regarding osteoarticular infections on prostheses were used in this study. SHA evaluates and provides recommendations on healthcare delivery, and gives French Health Certifications. To meet these requirements, a multi-disciplinary meeting (MDM) was created and included the branches of internal medicine, microbiology, orthopedic surgery, and the hospital pharmacy to discuss the patient-cases together. The objective was to standardize the care given and to define a therapeutic medical and surgical strategy for each patient.

This study is designed to evaluate the usefulness of the MDM decision in the care given to injured French military personnel suffering from osteoarticular infections.

METHODS

A retrospective study was performed including the French war casualties treated for an osteoarticular infection in the orthopedic and trauma department of the Percy hospital between the January 1, 2004 and the December 31, 2016.
French war-wounded were repatriated from Middle East and Sub-Saharan Africa. The diagnosis of osteoarticular infection was a combination of either clinical (purulent drainage, fever, erythema) or laboratory-based diagnosis (leukocytosis or neutropenia) and at least one positive bacteriological sample taken from the operatory room. Two groups were created: group A comprised the patients treated prior to institution of the MDM (prior to September 2010), and group B comprised the patients treated with the MDM procedure since September 2010. Culture-negative cases and non-documented infections were excluded (where antibiotics were delivered without identification of the pathogen), as well as group B patients who had not benefited from the MDM because they were hospitalized in other departments (mostly in intensive care unit). Those patients excluded from group B were not included in group A.

A weekly meeting was organized between orthopedic surgeons, microbiologists, internal medicine physicians, pharmacists and nurses. The MDM protocol was established to define the surgical procedure, duration and type of antibiotic medication (ATB), and the necessity of surgical revision. The MDM protocol prohibited swab samples taken on open wounds and fistula holes at the bed-side.

**Demographic Data and Bacteriology**

Age, number of ballistic traumas, open fractures, and associated injury and the New injury Severity score (NISS) were used to compare the two groups.

The rate of infection was calculated among all combat injuries, and bacterial cultures were analyzed. The number and types of pathogen were analyzed for the cohort and for each group.

**Treatment Parameters**

The following therapeutic parameters were studied: the number of procedure(s) (including iterative debridement, dressing or bone and soft-tissue reconstruction); the number of bacteriological samples taken during each procedure; the number of swab samples used to make the diagnosis.

The global hospitalization duration (including days in intensive care unit or in other surgical departments) was analyzed.

Three criteria allowed to take into consideration the medical viewpoint (optimization of bed capacity and optimization of the hospitalization) and the patient’s viewpoint (reduction of the hospitalization duration). The hospitalization duration/number of procedure(s) ratio was used to determine the period between each surgical procedure. The duration of intravenous (IV) and oral ATB was compared. The ATB/hospitalization duration ratio was used to look for efficiency and effectiveness of the hospitalization (better when close to 1).

Providing home-healthcare was favored when the conditions allowed it.

**Evaluation by the Healthcare Professionals**

A survey evaluated the perception that each practitioner (of all the MDM specialties) of the usefulness and the pitfalls of the MDM in his practice of osteoarticular infections management. Six questions were asked to the different medical staff and nurses present during two MDM consecutive sessions (Table I). Each answer requires a mark that ranges between 0 (totally disagree) and 5 (agree strongly). The global evaluation of the MDM was divided into three categories: very satisfactory (scores between 21 and 30), satisfactory (scores between 11 and 20), not satisfactory (0 and 10). The last question was open-ended in order to allow the different actors present in the meetings to express their needs and suggest improvements that could be made to the MDM meetings.

**Statistical Analysis**

The data were collected using Excel (Microsoft Office 2010). Statistical analyses were done with StataIC 15.1 (StataCorp LLC): the T-test of STUDENT (IC 95%) was used when the values collected had a normal distribution. The Wilcoxon test was also used (95%CI) when the values had a non-normal distribution. Mid-P exact test (95%CI) was used for comparison of non-parametric values.

**RESULTS**

**Demographic Data**

During the study period, 522 French casualties were evacuated from various theaters of operations for extremity war injuries. Among them, 46 (8.8%) were diagnosed with an osteoarticular infection: 19 in group A and 19 in group B. 8 patients were treated without MDM procedure after September 2010 (Fig. 1). All were male patients with a median age of 28.7 years [range: 20.7–52.4 years]. All injuries in both groups concerned the lower limb. There was no difference between the two groups concerning age, the mechanism and the associated injuries (Table II).

**TABLE I. Survey Contents**

<table>
<thead>
<tr>
<th>Question</th>
<th>Content</th>
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<tbody>
<tr>
<td>1</td>
<td>To what extent has your surgical or medical approach to treating the war-wounded improved?</td>
</tr>
<tr>
<td>2</td>
<td>To what extent has your colleagues’ treatment of the war wounded improved?</td>
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<tr>
<td>3</td>
<td>To what extent has the hospitalization duration for the war-wounded with osteoarticular infection been reduced?</td>
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<tr>
<td>4</td>
<td>To what extent has the number of surgical procedures performed diminished and the timescale between each procedure been reduced?</td>
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<tr>
<td>5</td>
<td>The frequency (weekly) of the MDM is sufficient</td>
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<tr>
<td>6</td>
<td>To what extent is the MDM composition appropriate for the care for the war-wounded with osteoarticular infection?</td>
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</tbody>
</table>
Bacteriology

Initial tests (performed at the patient admission) found an infection in 15 patients, an infection with 2 pathogens in 11 patients, and an infection with 3 or more pathogens in 12 patients. Among the 29 victims of ballistic trauma, 16 were evacuated from Middle East and 13 from Sub Saharan Africa. Enterobacter cloacae was the most common pathogen found in the test results of the osteoarticular infections (n = 13 cases, 45%) (Figure 2). Pseudomonas aeruginosa (n = 8 cases, 28%), Escherichia coli (n = 7 cases, 24%) were also frequent. Infections due to Acinetobacter baumanii (n = 4 cases, 14%) and Enterococcus faecium (n = 3 cases, 10%) were only diagnosed in casualties evacuated from the Middle East.

Treatment Parameters

The median number of samples taken per procedure was significantly higher in group B (p < 0.001). The median number of swab samples used to make the diagnosis was significantly lower in group B (p < 0.001) (Table III).

Evaluation by the Healthcare Professionals

Fourteen healthcare professionals completed the survey including nine orthopedic surgeons, three physicians and microbiologist, one pharmacist, and one health care executive representing the nursing sector. The survey results are summarized in Table IV.

Upon closer examination and analysis of the questionnaires, the participants believed that there was no modification with regards to the number of procedures since the creation of the MDM (question 4). None believed the MDM to have little value during the treatment of osteoarticular infections. Two orthopedic surgeons believed the MDM to be satisfactory, and the 12 others estimated the MDM very satisfactory.

With regards to the open question, five surveys were left blank. The recommendations made concerned the inclusion of anesthetists and plastic surgeons (two participants), a more theoretical approach to literature reviews (four participants) and discussion prior to patient hospitalization for cases of chronic infections (four participants).

DISCUSSION

The ratio of osteoarticular infections in French war casualties (7.3%) is comparable to that reached by Murray et al., who describe an infection rate between 2 and 15% in American soldiers wounded in Iraq and Afghanistan. The bacterial ecology found in this cohort is comparable to the recent American data focused on those wounded during the operations Iraqi and Enduring freedom. However, the latter study only focuses on wounded from the Middle East, whereas the survey conducted by the French units also include those wounded in sub-Saharan Africa.

Osteoarticular infections among war casualties are due to a multitude of factors. The results cannot allow us to conclude with regards bacteriological and geographical correlations, as the environmental factors are too numerous and non-comparable between patients. Recent studies found that war wounds are contaminated within the first few hours by Gram-positive organisms present on the skin (coagulase-negative staphylococci). However, osteoarticular infections are often due to Gram-negative organisms (Enterobacter, Acinetobacter baumanii, Escherichia coli). Kaspar et al. have shown that a nosocomial transmission exists during the initial treatment, but also during the evacuation process.

This study shows that the implementation of the MDM is associated with a change in the practice of orthopedic surgeons...
concerning the treatment of osteoarticular infections. The number of samples taken for testing was significantly increased and is henceforth equal to the recommended number by the French SHA. Indeed, the step up from 1.34 samples to 3.06 samples after the implementation of the MDM allowed us to adhere to the 3–5 sample guideline put forward by the SHA and corresponding literature. Swab samples taken from open wounds and fistula holes were also abolished thanks to these new practices. Tetreault et al showed that there is a correlation of only 47.3% between swab culture and deeper samples, with a significant increase of poly-pathogen culture in swab samples. The use of swab samples can lead to a misdiagnosis or the prescription of inappropriate ATB.

The present objective and subjective analyses concur with regards to the evolution of the number of procedures required per patient. The implementation of the MDM did...
not have as a goal to radically modify the surgical treatment of patients with osteoarticular infection, but rather to optimize the global management by conserving the experience and field knowledge gained by the French Military Health Service.

These results did not permit to show a decrease of the duration and the optimization of hospitalization for the infected patients since the implementation of the MDM. The low statistical power due to a small number of patients in each group, despite the long time-frame for the study, did not allow to obtain significant results. Long periods of hospitalization could be explained by the therapeutic strategy with weekly discussions with long-stay patients in order to optimize the IV ATB and the planning of surgical procedures to clean the wound or reconstruct segments of the limb. Conversely, the rates that measure the ATB duration compared to the hospitalization duration show a trend to hospitalize the patient for the entire duration of the ATB in both groups, regardless of whether it is oral or IV. In addition, the patients were often hospitalized for the follow-up of the treatment of the infection. Obtaining a follow-up procedure after a complete clinical, biological and radiological evaluation and a discussion of the case imposes a short-duration hospitalization (48–72 hours).

Future perspectives would be the use of home-healthcare, outpatient parenteral antimicrobial therapy and surgical and infectious follow-up through consultations. This remains limited because the treatment of patients with war-related osteoarticular infection is almost exclusively carried out in the Percy hospital. Providing home-healthcare was difficult in the population because of the geographical origin of the patient. Even though the patients live throughout France, medical coordination in military compounds with the stewardship teams was difficult.

Health-care professionals generally rate the usefulness of an MDM during the treatment of osteoarticular infections very highly, but the open-ended question allowed us to push the understanding and appreciation of their specific needs. The presence of anesthetists to manage pre-surgery ATB once deep samples has been taken, to provide expertise in the prepping of the patient for often long and aggressive procedures, is an example of the improvements possible to the MDM and the optimization of the patient’s treatment. The presence of plastic surgeons could also be useful considering that most infected war wounds require iterative debridement followed by soft tissue coverage. The planning of a surgical strategy before the patient’s hospitalization and intercurrent clinical follow-up are not systematic but might be added in a near future.

**CONCLUSION**

The treatment of war casualties with osteoarticular infections cannot be fully governed by protocols or universal recommendations, due to the heterogeneous nature of the environment in which these patients were deployed. However, the creation of a MDM as it was described by the SHA seems to have had a beneficial impact on surgical practices, increasing the number of deep samples done during surgical procedures. This in turn helps the search of more relevant organisms, crucial in order to provide a proper ATB medication. It enables the surgeon to not be alone when treating war-related osteoarticular infections. The perspectives of improvement of the MDM concern the use of home-healthcare and outpatient parenteral antimicrobial therapy. A surgical and infectious follow-up through consultations should be used to decrease the duration of hospitalization.

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