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ORIGINAL STUDY

Could the orthopaedic surgeon deployed in austere setting perform flaps on the leg?

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The orthopaedic military surgeons deployed in operations are led to perform soft tissue coverage on the lower limb. The purpose of this study was to evaluate if flaps performed by surgeons' non-specialist in reconstructive surgery are associated with good outcome. All patients operated for a flap on the leg in French Forward Surgical Team deployed in theatre of operations between 2003 and 2013 were retrospectively reviewed. Forty-nine patients were included, for a total of 54 flaps' procedures. Indications were open fractures in 25 cases and osseous infections in 29 cases. No flap was performed on French soldiers. All the flaps were pedicle. Outcome was favourable for more than 90% of flaps with no statistical difference between muscular and fasciocutaneous flap and with regard to the indication. In conclusion, an orthopaedic surgeon deployed in austere setting with significant good outcome can perform reconstructive surgery with legs' flaps.

Keywords : flap ; forward surgical team ; leg ; training ; military surgery.

INTRODUCTION

Orthopaedic military surgeons are deployed in theatre of operations within a forward surgical team (FST) in a Role 2. FST is a small mobile surgical structure including one orthopaedic surgeon and one general surgeon, with limited resources. FST surgical activity is firstly dedicated to the primary treatment of combat casualties (French or foreign soldiers) and secondly to the surgical treatment of local civilians with MAP (Medical Aid to the Population). For management of French combat casualty, the strategy involves an orthopaedic damage control with early debridement, revascularization, and stabilization with exofixation *(1)*. After strategic MEDEVAC toward France, definitive repair procedures of soft tissue are performed in Role 4 by specialized multidisciplinary teams, preferably 5 to 10 days after the initial procedure *(2,4,8-9)*. However, management of foreign servicemen and local civilians may sometimes imply a prolonged hospitalization length of stay in the FST. Moreover, deployed surgeons are also led to treat neglected tibia fractures of local civilians with osteotites or septic pseudarthrosis that can require soft tissue coverage procedures. In such

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a case, the orthopaedic surgeon has to engage, in an austere environment, a real reconstructive strategy, including soft tissue coverage procedures. The aim of this study was to analyse outcomes of legs' flaps performed by an orthopaedic surgeon in a French Forward Surgical Team. We hypothesized that legs' flaps performed by orthopaedic surgeons non-specialized in reconstructive surgery are associated with good outcome.

MATERIALS AND METHODS

A retrospective review was performed and included all patients who underwent a procedure of flap coverage for soft tissue defects, between 2003 and 2013 in a French Forward Surgical Team, in Chad, Ivory Coast, Afghanistan and Kosovo. Enrolment was performed, including all nationalities (*i.e* French, Coalition, Local National Army, local civilian population). Inclusion criteria were patients with either an early coverage of soft tissue defects on an open tibia fracture either a coverage procedure for a soft tissue defect of the leg with tibia osteotites or septic pseudoarthrosis. Only orthopaedic surgeons, non-specialized in reconstructive surgery, performed all flaps. All types of flaps were included (muscular and fasciocutaneous flap, free and pedicle flaps). Data have been extracted from a Filemaker Pro® database (File Maker Inc, Santa Clara, CA, United States) containing the whole operative reports of patients operated during the period of the study. The studied data were patients' age and status (French and foreign soldiers, local civilians), operative indications (osteoarticular infection and open fracture), characteristics of the flap (muscular or fascio-cutaneous flap, free or pedicle flap) and the outcome at 3 months (favourable or failure). Failures were defined as partial or total necrosis of the flaps requiring a new coverage procedure. Statistic analyses were performed using an Excel database (Microsoft, Redmond, WA). Quantitative variables were described in relation to the mean and standard deviation, and to the median and extreme values. A Fisher exact test was used for inter-group comparison and the significance threshold was set at $p \leq 0.05$. Commander approval was obtained for this study.

RESULTS

During the time of study, 54 flaps coverage of the leg were performed for 49 patients. Five patients had two flaps coverage either at the same time (four cases with a large soft tissue defect) or in a second time after the failure of a first flap (one case, with a medial saphenous flap after necrosis of a soleus flap for a septic pseudarthrosis of the tibia). Patients' mean age was 29 years (SD=15) with a median age of 28 years (min-max=4-68 years).

Indications for flap of the leg were open fractures of the tibia in 25 cases and osseous infections in 29 cases (16 osteites, 10 septic pseudarthrosis, 3 arthritis). All open fractures were operated in emergency, with a flap performed within the 5 to 10 following days.

Flap was performed for 43 local civilians, six foreign soldiers and for zero French soldiers.

All the flaps were pedicle. No free flap procedures were carried out. Flaps performed on the leg were:

– 35 muscle flaps: 4 lateral and 20 medial gastrocnemius flaps, 11 soleus flaps (Figure 1).

– 19 fasciocutaneous flaps: 11 sural with distal pedicles flaps, 5 bi-pedicle fascio-cutaneous flaps, 1 medial saphenous flaps, and 2 lateral supra malleolar fascio-cutaneous flaps.

Flaps outcomes were favourably in 49 of cases. One medial saphenous flaps with a total necrosis required a new soleus flap with a good outcome and four others flaps with partial necrosis required controlled wound healing procedure or vacuum assisted closed therapy to achieve the coverage. No statistical difference of outcomes exists between fasciocutaneous or muscular flaps in legs and between open fractures and bone infection (Table I).

DISCUSSION

The aim of this retrospective study was to describe and to assess the outcome of flaps performed of the leg in austere setting. In our study, orthopaedic surgeons non-specialized in reconstructive surgery deployed in theatre of operations performed 54 flaps coverage of lower limb defects, with a good result in 91% of cases.

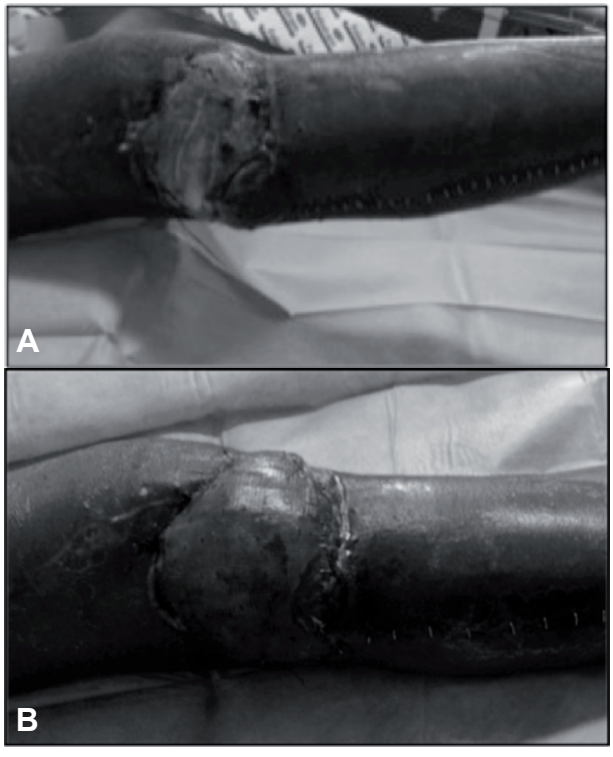

Fig. 1. — A 20 years' old foreign soldier. Bullet-induced joint injury of the left knee. The patellar tendon and the lateral tuberosity of the tibia are exposed. A lateral gastrocnemius muscle flap was performed five days after the injury and skin graft was delayed 7 days after. Satisfactory outcome.
A: Lateral gastrocnemius muscle flap performed
B: Outcomes after skin graft at 15 days.

As we had already reported *(2,10),* flap surgery remains rare in theatre of operation but sometimes necessary. In most cases, flaps concern the leg because tibia is a superficial bone easily exposed and with problem of soft tissues defect after injury. Indications remain rare because simpler and less aggressive soft tissue coverage procedures, like controlled wound healing, vacuum assisted closed therapy or skin grafts, are often sufficient to cover moderate losses of soft tissue. The main indications for flaps are large losses of soft tissue or those exposing bones, tendons or vasculonervous pedicles.

First of all, in our study, no flap coverage was performed on French soldier. French combat casualties are evacuated toward France within the 24-48 hours after injury, for further coverage management by specialized teams in Military Teaching Hospitals in France. Coverage procedures are then performed between the 5th and 10th days *(2,4,8-10)*. In ROLE 2 and ROLE 3, orthopaedic surgeons non-specialized in reconstructive surgery have to perform flap coverage procedure for local civilians and foreign soldiers who cannot be evacuated. Management of soft tissue coverage has to be integrated in a real reconstructive strategy and flaps are then performed in precarious conditions. In addition, orthopaedic surgeons are led to manage during their deployment late fractured bone complications in local civilians such as tibia pseudarthrosis and osteoarticular infections with soft tissue defects requiring flap coverage procedures in roles 2 *(11)*.

Secondly, no free flaps were performed in our study. Only pedicle muscular and fasciocutaneous flaps were performed because these procedures seem to be more reliable without microsurgery device. In austere setting, free flaps remain long and complex procedures with more uncertain outcomes. Nevertheless, in literature, two authors report free flaps surgery in isolated situations. Kem et al *(6)* have reported 31 free flaps performed on 29 local patients in roles 2 and 3 in Iraq and Afghanistan between 2006 and 2011 but they concluded that micro vascular reconstructive surgery was feasible in role 2 only if specific equipment of microsurgery and microsurgery-trained specialists were available, which is not the case in our French structures. Tajsic et al *(14)* in 2009 reported his personal experience with 34 patients with free flaps during the Balkan conflict with only 8% of complications, but this study is mono-operator and operations were performed with personal microsurgery material brought by the operator. This work demonstrated that such surgery could be performed in precarious setting if the necessary microsurgery devices were available. Moreover, there are no convincing data in the literature indicating that free flaps are better than pedicle flap. In a series of 67 war-induced leg fractures managed in specialized structures after evacuation, Burns et al *(5)* found significantly more complications and amputations after free flaps than after pedicle flaps. On the other hand, Trabulsy et al *(16)* 18% of pedicle flaps failed versus 3% of

Table I. — Indications, type of flaps and outcomes

Type of flaps		Fasciocutaneous flaps		Muscular flaps		*p*
Outcome		Necrosis	Good	Necrosis	Good	
Indication	Bone infection	1	9	2	17	0,25
	Open fracture	2	7	0	16	
Total		3	16	2	33	54
P		0,53				

free flaps. But, this last study reported results of specialized surgeon in reconstructive surgery in ideal setting. For Trabulsy et al *(16),* some factors could explain the risk of failure like the perforators supplying the pedicle flaps that could be injured during high-energy traumas or like inflammatory oedemas and important contaminations that could increase the risks of vascular thrombosis. Actually, we prefer to recommend in first intention pedicle flaps rather than free flaps because they are more reliable in austere setting, as in our study. Indeed, more than 90% of flaps performed in our series have progressed favourably. These pedicle flaps generally allow covering most of soft tissue defects of the leg while remaining fast procedures that do not require a particular expertise *(6-7,12,14-15)*.

Thirdly, no statistical difference in our study of outcomes was found between fasciocutaneous or muscular flaps in legs and between open fractures and bone infection. We can't recommend the use of muscular flaps rather than fascio-cutaneous ones for soft tissue defect of the leg some is the indication. In the literature, some data seem to indicate that muscular flaps are better in open fracture of the tibia than fasciocutaneous flaps but it is always discussed *(4)*. So, indication depends more than the location of the defect and its size and there is clearly a need for studies that better define the indications.

This work has limitations. The first one is inherent in works in precarious settings. The studied population is heterogeneous for associated medical pathologies and for the time lapse before management. We could not define prognostic factors in the outcome of flaps. Indications for the different flaps can also be discussed and only reflect the operator's view. Long-term lack of follow-up does not permit to assess the morbidity of these procedures. Finally, data collection may not be exhaustive since it is a retrospective study based on a database completed by the surgeons.

Despite of these limits, this study demonstrated that pedicle flap surgery of the leg is a reliable surgery even in precarious settings and carried out by an orthopaedic surgeon non-specialized in reconstructive surgery. Education of surgeons deployed must also include the learning of the main procedures. Presently, French surgeons' training rests on an Advanced Course on Surgery in External Missions (CACHIRMEX) *(1,3,13)*, with a module teaching of these pedicle flaps. This training seems to be efficient in the light of the good outcomes this surgery achieved in our series. The paramedical staff must also be made aware of this surgery and trained in flap supervision in order to detect early complications.

In conclusion, an orthopaedic surgeon non-specialized in reconstructive surgery can perform flap for soft tissue defect on the leg in austere settings successfully. Pedicle flaps are the most reliable for military surgeons deployed in a combat zone, without microsurgery device. This paper could help to inform provision of surgical resources for future military operations.

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