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War-related extremity injuries in children: 89 cases managed in a combat support hospital in Afghanistan

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ABSTRACT

Background: Meeting paediatric needs is among the priorities of western healthcare providers working in Afghanistan.

Hypothesis: Insufficient information is available on paediatric wartime injuries to the extremities. Our objective here was to describe these injuries and their management on the field.

Materials and methods: We retrospectively reviewed consecutive cases of injuries to the extremities in children (<16 years of age) due to weapons and managed at the Kabul International Airport (KaIA) Combat Support Hospital between June 2009 and April 2013. We identified 89 patients with a mean age of 10.2 ± 3.5 years and a total of 137 elemental lesions.

Results: Explosive devices accounted for most injuries (78.6%) and carried a significantly higher risk of multiple lesions. There were 54 bone lesions (traumatic amputations and fractures) and 83 soft-tissue lesions. The amputation rate was 18%. Presence of bone lesions was associated with a higher risk of injury to blood vessels and nerves. Of the 89 patients, four (4.5%) died and eight (9%) were transferred elsewhere. Of the 77 remaining patients, at last follow-up (median, one month; range, 0.1–16 months), 73 (95%) had achieved a full recovery (healed wound and/or fracture) or were recovering with no expectation that further surgery would be needed.

Discussion: Despite the absence of paediatric surgeons, the combat support hospital provided appropriate care at the limb salvage and reconstruction phases. The highly specialised treatments needed to manage sequelae were very rarely provided. These treatments probably deserve to be developed in combat support hospitals.

Level of evidence: IV, retrospective study.

1. Introduction

Casualties to civilians, including children, are part of the collateral damage that occurs during modern asymmetric warfare. During the past decade, over 2,000,000 children are estimated to have died due to wars and their consequences [1]. Few epidemiological data are available on paediatric healthcare in combat zones. Creamer et al. [2] reported that 10% of patients admitted to a combat support hospital (CSH) were children. Penetrating wounds due to combat projectiles predominated (76.3% of cases) and the extremities were the most common sites of injury (38.3%) [2].

Combat-related injuries to the extremities in children account for a large proportion of the care provided in CSHs [2]. Nevertheless, few studies have focussed on these injuries, and their results are conflicting. We hypothesised that insufficient information is available in this area. In a study of 37 paediatric patients with non-combat-related gunshot wounds to the extremities, including 29 with fractures, Washington et al. [3] reported that outcomes were favourable overall. Thus, only five patients experienced soft-tissue infection, none had osteitis, and all the fractures healed. Also in the non-combat setting, Arslan et al. [4] concluded from a study of 27 gunshot fractures in 22 children that the treatment was never simple. Late-stage surgery was acquired to achieve union of 6/27 fractures, and several serious complications were noted at last

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follow-up (including non-union in two patients and amputation in one patient).

Here, our objective was to describe the nature and management of combat-related injuries to the extremities in children admitted to a war-zone surgical facility in Afghanistan.

2. Patients and methods

We performed a retrospective single-centre study of patients managed between June 2009 and April 2013 at the Kabul International Airport (KaIA). The patients were identified in the French military healthcare database OPEX (*service de santé des armées français*), which collects information on all patients who undergo surgical procedures in war theatres abroad. We included all patients younger than 16 years of age who required surgery for combat-related injuries to the extremities. Patients with isolated injuries to the pelvis or shoulder girdle were excluded.

2.1. The hospital

The patients were managed at the KaIA CSH, a North Atlantic Treaty Organisation (NATO) facility run by the French military to support troops deployed in the Kabul area of Afghanistan [5]. The main priority is damage control to allow the safe medical evacuation of wounded coalition members to a hospital in continental France, where definitive treatment can be provided. Another goal consists in providing care to civilians, including children, who must then be transferred to local facilities despite the limited healthcare resources available there.

2.2. Patients

During the study period, 155 children received surgical treatment for injuries to the extremities. Combat projectiles were the main causes of injury, with 89 cases. This group of 89 children had a mean age of 10.2 ± 3.5 years and a male-to-female ratio of 3.4. Injuries due to explosive devices (blast effect and/or shrapnel) were far more common ($n = 70$) than were firearm injuries ($n = 19$).

Of the 89 children, 68 were admitted primarily to the KaIA CSH and 21 were transferred after receiving initial treatment at another facility.

2.3. Assessment methods

In the overall cohort, we analysed the mechanisms of injury, topographic distribution of lesions, types of elemental lesions, concomitant injuries, Injury Severity Score (ISS) [6], and all surgical procedures including those performed elsewhere before admission to the KaIA CSH. Elemental lesions were classified as traumatic amputations, fractures (diaphysis, metaphysis/epiphysis, and hand and/or foot), and soft-tissue injuries (STIs). In patients with multiple STIs (multiple shrapnel wounds), we analysed only the main injury in each segment of the involved limb. Lesions to the pelvis or shoulder girdle were classified among the concomitant injuries. We then categorised the elemental lesions into two groups, namely, bone lesions (traumatic amputations and fractures) and STIs. We recorded the hospital stay length, number of operating-room admissions, and number and type of elemental surgical procedures.

When evaluating the outcomes, we excluded the patients who died and those who were lost to follow-up after being transferred elsewhere. We considered only the wound and/or fracture-healing phase. Full recovery at last follow-up was defined as complete healing of the STIs and/or fractures, ongoing recovery as no expectation that further surgery would be required to achieve a full recovery, and ongoing treatment as doubt regarding the surgical outcome. No functional evaluations were performed.

For statistical comparisons, we used Fisher's exact test for qualitative variables and Student's test for quantitative variables. Values of $P \leq 0.05$ were considered significant.

3. Results

3.1. Description of the lesions

We identified 137 elemental lesions (Table 1), i.e., 1.5 lesions/patient on average. More than one limb was injured in 26 patients. Table 2 lists the lesion sites. The hand was the most common site involved (24%), although lower-limb injuries (58%) were more common overall than upper-limb injuries. No distinct wound patterns were identified.

3.1.1. Bone injuries (n = 54)

There were 19 cases of traumatic amputation in 14 children, including 11 at the upper limb (nine below and two above the wrist) and eight at the lower limb (five below and three above the knee).

A total of 35 fractures or fracture sites were present in 31 children. All fractures were open, and the knee was the most common site (60%). Blood vessel and nerve injuries were present in 37% and 20% of fractures, respectively, with no statistically significant differences according to fracture location at the diaphysis, metaphysis/epiphysis, or hand and/or foot. In contrast, bone injuries were significantly associated with a higher risk of injury to blood vessels ($P < 0.001$) and nerves ($P < 0.05$), compared to STIs.

Explosive devices caused all 19 traumatic amputations and 22 of the 23 bone injuries of the hand and/or foot.

Of the 54 bone injuries, 19 (35%) were accompanied with an STI at another site.

Table 1
Description of the lesions in 89 children with combat-related injuries to the extremities.

	n (%)		
Bone injuries	54 (39)		
Traumatic amputation		19 (35)	
Fracture		35 (65)	
Diaphysis			14 (40)
Metaphysis/epiphysis			10 (29)
Hand and/or foot			11 (31)
Soft-tissue injuries	83 (61)		
Total	137 (100)	54 (100)	35 (100)

Table 2
Sites of the lesions in 89 children with combat-related injuries to the extremities.

Site	Bone injuries		Soft-tissue injuries	Total, *n* (%)
	Amputation, *n*	Fracture, *n*	*n*	
Shoulder			3	3 (2)
Arm		1	11	12 (9)
Elbow		2	2	4 (3)
Forearm		2	2	4 (3)
Wrist			2	2 (1)
Hand	11	8	13	32 (24)
Hip		1	5	6 (4)
Thigh	3	6	15	24 (18)
Knee		6	4	10 (7)
Leg	4	5	21	30 (22)
Ankle		1	3	4 (3)
Foot	1	3	2	6 (4)
Total, *n* (%)	19	35	83	137 (100)

Table 3
Concomitant lesions in 89 children with combat-related injuries to the extremities.

Site	n	%
Skull	21	16.1
Eyes	35	26.7
Face and neck	12	9.2
Thorax	24	18.3
Abdomen	32	24.4
Spine	1	0.7
Pelvis	6	4.6
Total	131	100

Table 4
Surgical procedures (other than hardware removal) in 89 children with combat-related injuries to the extremities.

Surgical procedures	Bone injuries (n = 54)	Soft-tissue injuries (n = 83)
Procedures related to limb salvage		
Debridement and lavage	93	120
Surgical amputation	6	
External fixation	13	
Cast ± reduction under anaesthesia	14	2
Negative-pressure wound therapy	35	30
Vascular repair	3	3
Fasciotomy	3	1
Limb reconstruction procedures		
Stump reconstruction	18	
Delayed skin closure	7	15
Skin transplant	6	10
Pedicled flap	4	5
Internal fixation	9	
Nerve repair	4	5
Tendon repair	3	4
Delayed bone reconstruction	7	
Total	226	195

3.1.2. Soft-tissue injuries (STIs) (n = 83)

There were 83 STIs in 64 children, of whom 14 (22%) had two or more lesion sites. Injuries to blood vessels and nerves were present in 3.6% and 7.2% of cases, respectively.

3.1.3. Concomitant injuries

Injuries to the torso and/or head were present in 49 children (Table 3), and 17 children had more than one concomitant lesion. The median ISS was 9 (interquartile range, 1–66) with no difference between ballistic and explosive injuries. Concomitant lesions were significantly more common in patients with explosive injuries than with ballistic injuries ($P < 0.01$).

3.2. Surgical management

Table 4 lists the surgical procedures. Median hospital stay length was 9 days (range, 1–53 days) and the median number of operating-room admissions was two (interquartile range, 1–12). The ratio of the total number of surgical procedures over the number of lesions was significantly higher in the group with bone injuries ($P < 0.004$).

3.2.1. Traumatic and/or surgical amputation

Six surgical amputations were required. All surgical amputations were performed immediately or within the first seven days. The amputation rate was 18%. Reconstruction procedures were performed in only two patients: one consisted in lengthening the first metacarpal using autologous iliac bone to improve thumb-to-finger pinch grip after amputation of multiple fingers during the initial admission; the other was a delayed unilateral Krukenberg procedure after bilateral hand amputation in a patient who was

transferred from another healthcare facility for ophthalmological management and whose stumps were fully healed.

3.2.2. Soft-tissue procedures

No statistically significant differences were found between the bone injuries and the STIs regarding soft-tissue procedures (debridement-lavage; coverage; and tendon, nerve, and/or blood vessel repair). Of the six revascularisation procedures, two failed: thigh amputation was required early after superficial femoral artery revascularisation in one patient, and a patient with common femoral artery and vein injuries at the femoral triangle died of haemorrhagic shock during surgery.

3.2.3. Procedures on bone

Of 29 fractures managed conservatively, 14 were treated non-operatively and 15 by fixation. Two femoral shaft fractures were treated with external fixation initially then by internal fixation (plate in 1 case and stable elastic intramedullary nailing in the other); both healed within two months. A bone defect in the radial diaphysis required plate fixation with bone grafting two months after the injury (ongoing treatment at last follow-up). Internal fixation was used for nine fractures, of which eight had available follow-up data and no evidence of infection. Of the six fractures managed using definitive external fixation, four had available follow-up data including two that required revision surgery with bone grafting (ongoing treatment). Treatment to prevent malalignment and/or limb length inequality (epiphysiodesis) was performed in a single case concomitantly with removal of the external fixator.

3.3. Outcomes at last follow-up

Of the 89 children, four (4.5%) died. The cause of death was blood vessel injury at the femoral triangle in one patient and a concomitant injury in the other three patients (one case each of penetrating head injury, penetrating heart injury, and a decubitus-related complication of a spinal and spinal-cord injury). In addition, eight (9%) patients were transferred to local hospitals and lost to follow-up.

In the remaining 77 patients, median follow-up was one month (range, 0.1–16 months). Among them, 73 (95%) were classified in the fully recovered or ongoing recovery category and four in the ongoing treatment category.

4. Discussion

As with most studies of war-zone healthcare, our case-series is retrospective. Nevertheless, the large number of patients allowed us to map the injuries and to accurately evaluate the surgical treatments aimed at limb salvage and reconstruction, thus partially meeting the study objective.

Explosive devices were by far the most common causes of injury, as is usually the case in modern asymmetric warfare [2,5]. In this setting, the same body sites seem to be involved in adults and children [7], probably because the causes are similar. Using a similar design to ours, Belmont et al. [7] found a 6% amputation rate in members of the US military wounded in Afghanistan or Iraq. The higher amputation rate of 18% in our population suggests increased exposure or perhaps vulnerability of the extremities in children compared to adults. This difference cannot be ascribed to differences in the causes of injury; the use of body armour (which does not protect the limbs); or the outcomes of vascular injuries due to combat projectiles, as the 95% limb salvage rate in our children is comparable to that reported in adults [8]. The high frequency of concomitant injuries (55%) and high median ISS (9) are ascribable to the predominance of explosive injuries and, importantly, illustrate the far greater seriousness of the lesions in our patients

compared to those seen usually in civilian practice. In a study of 27 fractures due to gunshot wounds in children, Arslan et al. [4] found concomitant lesions in 18% of cases and a 4% surgical amputation rate. Among patients with bone injuries in our study, 37% had blood vessel injuries and 20% nerve injuries. These high frequencies are also in contrast to patterns seen in civilian practice but are the rule with combat injuries, as reported by Weil et al. [9] in a study of terrorist attacks. Consequently, children with limb injuries due to combat projectiles must be carefully evaluated for damage to blood vessels and nerves.

The surgical management was not markedly different from that used in adults. However, a few specific features in children deserve to be pointed out [10,11]. Debridement should be performed routinely as part of the initial treatment of combat-related injuries in children. Debridement can be more economical than in adults, given the better potential for tissue healing; thus, free bone fragments can be returned to their normal position. The higher risk of compartment syndrome in children supports nearly routine fasciotomy of at-risk compartments. During reconstruction, limited shortening (<2 cm) of the femur or tibia may be beneficial to improve construct stability or to decrease soft-tissue tension during wound closure. The growth spurt that usually follows a fracture in children compensates for the shortening [10]. The rigidity of the fixation should be proportional to the extent of the STIs, a fact that gives a major role to external fixation. The indications of temporary external fixation in children with open fractures remain to be defined. As with adults, careful patient selection is crucial [11]; femoral fractures may be a location of choice given the limits of external fixation at this site [10]. In keeping with a report by Creamer et al. [2], the median number of major surgeries was 2 per patient in our study. This high level of resource use carries a risk of operating-room backlog and hospital bed shortage. Our finding that 95% of children were fully recovered or undergoing recovery indicates that the management of wartime extremity injuries in children is satisfactory in CSHs such as the KaIA CSH. This result shows that the CSH meets its objective in terms of wartime care, that is, to achieve limb salvage by ensuring the healing of bone injuries and STIs. Similarly, Creamer et al. [2] stated that criteria for paediatric admissions to CSHs are injuries that pose an immediate threat to life, limb, or vision. The absence of a paediatric surgeon does not seem to have adversely affected the quality of care provided to children with combat-related extremity injuries. Limb salvage followed by limb reconstruction was achieved successfully by an orthopaedic surgeon experienced in managing paediatric trauma and having access to limited equipment, i.e., pins, external fixators, and elastic nails. The high frequency of penetrating hand injuries and of injuries to blood vessels and nerves requires the maintenance of specific surgical skills, which constitutes a central component of the training delivered to military orthopaedic surgeons expected to deploy to war zones.

The last phase of treatment consisting in managing the sequelae was very rarely provided. Arslan et al. [4] reported that outcomes were often favourable after gunshot wounds responsible for epiphyseal fractures, but the absence of long-term data on functional results and, therefore, on sequelae is a major limitation of their study. This limitation is unfortunately unavoidable when surgery is performed in disaster zones: the working conditions and long distances travelled by patients result in short follow-ups, many patients are lost to follow-up because they are transferred to other facilities, and communication barriers related to language and culture differences severely impair the ability to assess functional outcomes. In a report about trauma care at the Kandahar Airfield

CSH, Beckett et al. [12] emphasise the frequent lack of follow-up data after patient transfer. Given the state of disarray of the local healthcare services, the absence of follow-up data collection may appear ill-considered, as CSHs provide by far the highest level of care available locally [2,5,12]. The rationale for this strategy, however, is that the local healthcare services should continue to be involved and that the management of sequelae appears as a reasonable contribution to the overall process of care. Nevertheless, the management of sequelae remains a problem in Afghanistan, given the very small number of specialised centres. We believe that, in this setting, delayed surgical treatments designed to improve long-term outcomes may deserve to be given a greater role. The guiding principle would be to come as close as possible to definitive surgical treatment by the end of the initial hospital stay. Telemedicine has been validated as a method for obtaining the expertise needed to plan the therapeutic strategy [13].

5. Conclusions

This study provides the first evidence on the management of combat-related injuries of the extremities in children in a war zone. Despite the absence of a paediatric surgeon, the CSH provided appropriate care at the limb salvage and reconstruction phases. Treatment for sequelae was very rarely provided, as many patients were lost to follow-up. In war zones, the planning during the initial hospital admission of delayed surgical treatments aimed at improving long-term outcomes undoubtedly deserves a greater role.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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