

Factors affecting mortality of pediatric trauma patients encountered in Kandahar, Afghanistan

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Background: The North Atlantic Treaty Organization (NATO) Role 3 Multinational Medical Unit (R3-MMU) is a tertiary care trauma facility that receives casualties, both coalition and civilian, and provides humanitarian medical assistance when able to the Kandahar province in southern Afghanistan. We examined the cohort of pediatric patients evaluated at the facility during a 16-month period to determine the characteristics and care requirements of this unique patient population.

Methods: A database of Afghan patients younger than 18 years of age admitted to the NATO R3-MMU between January 2010 and April 2011 was developed from the Joint Theatre Trauma Registry. This patient cohort was analyzed to determine demographics, injury mechanism, injury severity, resource utilization and factors associated with mortality.

Results: A total of 263 children were admitted to the NATO R3-MMU during the study period, representing 12% of all trauma admissions during this time period. The median age was 9 years (range 3 mo–17 yr) with a predominance of male patients (82%). Battle-related trauma was responsible for 62% of admissions, with explosive blast injury constituting the predominant mechanism (42%). The average injury severity score was 12.3 ± 9.3 . Overall mortality was 8%. Factors associated with increased risk of death included admission acidosis, coagulopathy, hypothermia and female sex.

Conclusion: Children represent a significant proportion of traumatic injuries encountered in a modern war zone; many of them are critically injured. Organizations that provide health care in such environments should be prepared to care for this patient population where their mandates and facilities allow for it.

Contexte : L'Unité médicale multinationale de Rôle 3 (UMM R3) de l'Organisation du Traité de l'Atlantique Nord est un établissement de soins traumatologiques tertiaires qui reçoit les blessés des troupes de la coalition et de la population civile et offre une aide médicale humanitaire lorsqu'elle le peut à la population de la province de Kandahar, dans le Sud de l'Afghanistan. Nous avons étudié la cohorte de patients pédiatriques évalués à cet établissement durant une période de 16 mois afin de déterminer les caractéristiques et les besoins médicaux de cette population unique de patients.

Méthodes : Une base de données sur les patients afghans de moins de 18 ans admis à l'UMM R3 entre janvier 2010 et avril 2011 a été établie à partir d'un registre des traumatismes liés au théâtre des opérations conjointes (Joint Theatre Trauma Registry). Cette cohorte de patients a été analysée de manière à dégager les caractéristiques démographiques, le mécanisme des traumatismes, la gravité des blessures, l'utilisation des ressources et les facteurs associés à la mortalité.

Résultats : En tout, 263 enfants ont été admis à l'UMM R3 pendant la période de l'étude, ce qui représente 12 % de toutes les admissions en traumatologie pendant cette période. L'âge médian était de 9 ans (entre 3 mois et 17 ans) et les patients étaient majoritairement de sexe masculin (82 %). Les traumatismes liés aux combats ont représenté 62 % des admissions, les blessures consécutives à une explosion en étant le mécanisme principal (42 %). Le score moyen de gravité des blessures était de $12,3 \pm 9,3$. La mortalité globale a été de 8 %. Les facteurs associés à un risque accru de décès incluaient l'acidose au moment de l'admission, la coagulopathie, l'hypothermie et le fait d'être de sexe féminin.

Conclusion : Les enfants représentent une proportion significative des traumatismes rencontrés en zone de guerre, et beaucoup d'entre eux sont grièvement blessés. Les organismes qui fournissent des soins de santé dans de tels environnements devraient être prêts à soigner cette population de patients là où leur mandat et leurs installations le permettent.

Between August 2007 and July 2011 the Canadian Armed Forces (CAF) engaged in combat operations in Kandahar, Afghanistan. As the lead nation in this province, the CAF contribution included deploying an infantry battle group as well as taking command of the Kandahar Airfield Role 3 Multinational Medical Unit (R3-MMU).

This rudimentary yet robust field hospital provided tertiary care to all deployed North Atlantic Treaty Organization (NATO) soldiers in the Kandahar area as well as some Afghan National Security Forces (ANSF) whose injuries exceeded the local military hospital's ability to care for these patients. Afghan local nationals (civilians) were mainly cared for in Mirwais Hospital in Kandahar City unless they required subspecialist consultation. Once stabilized, efforts were made to repatriate patients from the R3-MMU to local facilities to ensure resources were available to treat any incoming injured NATO soldiers, which was the primary mission. The CAF Medical Rules of Eligibility (MROE) were followed to determine which patients were eligible for care at each site. There were incidents where critically injured children were simply brought to a CAF Forward Operating Base by a parent searching for medical care. In these cases the child would often be transported to the R3-MMU. During this period, more than 4000 patients were treated, most of whom were ANSF or civilians.¹⁻³

On Oct. 15, 2009, Command of the R3-MMU was transferred to the U.S. Navy Medical Corps (USNMC). Canadian involvement continued as the CAF remained the second largest contributor of medical personnel at the R3-MMU. During this time a larger, purpose-built medical facility was constructed that was hardened against artillery and rocket attack in order that patient care could continue while under bombardment. This facility also had multiple trauma resuscitation areas, up to 4 operating theatres and a well-equipped ICU and ward capability. The USNMC also tripled staffing to make this facility immensely robust. This hospital became fully operational in May 2010.

With these changes to capacity and resources the MROE also changed. Specifically, a neurosurgeon, ophthalmologist, general pediatrician and pediatric critical care physician were all deployed to the R3-MMU by the USNMC. As such, the R3-MMU saw an increase in the number of pediatric patients who met MROE by virtue of their age, system affected (i.e., ocular, neurotrauma) or severity of injuries. As a result, the relative number of pediatric trauma patients seen at this facility became quite substantial.

In this study we describe the pediatric trauma patient population encountered at the R3-MMU. Specifically, we have characterized this population with respect to demographics, mechanisms and severity of injury, resource utilization and outcome. We also attempted to determine factors associated with increased mortality in pediatric trauma patients injured in war zones. It is hoped that these data will aid in future missions where Armed Forces health care personnel are called upon to treat pediatric civilian trauma.

METHODS

Data collection

Using Joint Theatre Trauma Registry (JTTR) data, we conducted a retrospective cohort study on all patients younger than 18 years who were admitted to the R3-MMU between Jan. 1, 2010, and Apr. 30, 2011. To be included in the JTTR, these patients had to be brought to the R3-MMU either direct from the field via NATO 9-line MEDEVAC (urgent radio communication from the battlefield requesting medical evacuation) or transfer from another facility, including NATO Forward Operating Bases, NATO Combat Support Hospitals, Afghan military facilities or civilian hospitals. Pediatric patients who were assessed or admitted to the R3-MMU for examination by a subspecialist, including a pediatrician or ophthalmologist, for nontraumatic illness were excluded from the analysis, as they are not captured in the JTTR.⁴

Data analysis

We used the data obtained from the JTTR to create a database of all pediatric trauma admissions during the study period. All data were stripped of identifiers before transfer from the JTTR to the investigators. Specifically, gathered data included patient demographic characteristics, mechanism of injury, injury scoring, transfer details (transfer from another facility or from point of injury), physiologic data on presentation (initial trauma room vital signs, Glasgow Coma Scale [GCS] score), initial trauma bay laboratory values, R3 trauma bay interventions, disposition, length of stay (LOS; intensive care unit [ICU] v. ward), ventilator days, discharge GCS score and discharge disposition. We performed statistical analyses using SAS software version 9.2 (SAS Institute). This study was approved by the Joint Combat Casualty Research Team as a performance improvement project and by the CAF Surgeon General.

RESULTS

During the 16-month study period a total of 2239 trauma patients were admitted to the R3-MMU. Of these patients, 263 (11.7%) were younger than 18 years. Patient demographic characteristics are presented in Table 1. The median age of this population was 9 years, with ages ranging from 3 months to 17 years. There was a strong sex bias, as 82% of patients were boys. The majority of injuries (62%) were categorized as battle injuries, which were sustained either by exposure to improvised explosive devices (IEDs), discarded or unexploded munitions or gunshot wounds, possibly as a result of being caught in firefights between Afghan or NATO allied forces and Taliban insurgents.

In accordance with the above finding, blast injuries were found to be the most common mechanism of injury, with

42% of admissions being blast-related. (Table 2). Gunshot wounds accounted for 17% of injuries. Non-battle injuries, including motor vehicle collision (MVCs; 16%) and falls (8%), were also seen relatively frequently. As a result of these mechanisms, most patients (53%) experienced penetrating injuries, whereas purely blunt injuries were encountered in 27% of patients. Burns and mixed pattern injuries each accounted for 10% of patients. It should be noted that blast-related trauma can inflict all of these injury categories, either separately or as part of a mixed pattern. The mean ISS for our pediatric patient population was 12.3, with a significant proportion (35%) of patients having an ISS of 15 or greater (Table 2). These data suggest that a large portion of the pediatric patient population seen at the R3-MMU was severely injured. In support of this finding, 36% of patients had a GCS of 8 or less, suggesting either severe head injury or physiologic instability severe enough to impair cerebral perfusion. The patient cohort analyzed in this study was also noted to have a mean base deficit of -4.8 suggesting relative under-resuscitation en route to definitive care. This is perhaps explained by the fact that many of these patients presented to NATO Forces for care through irregular means, such as simply being carried by a family member to a Forward Operating Base or nearby patrol.

Once admitted to the R3-MMU, pediatric patients had a mean LOS of 5.3 days, although this was highly variable, with LOS extending up to 43 days (Table 3). The mean LOS in the ICU was 2.1 days, and the mean number of ventilator days 1.3. Again, both of these factors were variable, with ICU LOS and ventilator days reaching up to 23 and 22 days, respectively. These data reflect the fact that severely injured pediatric trauma patients require a substantial amount of medical and critical resources during their

hospital admissions. With regards to discharge disposition, in-hospital mortality was approximately 8%, and 47% of patients were discharged home with a family member (Table 3). However, 38% of pediatric patients were discharged to the Mirwais Hospital, the nearest local facility, as many patients required ongoing treatment. Unfortunately, it was not possible to capture long-term outcome data on this population. As the R3-MMU had subspecialty capabilities in neurosurgery, ophthalmology and oral and maxillofacial surgery, patients were referred to the facility from other parts of Afghanistan. At the end of subspecialist treatment these patients were repatriated back to the original facility. These patients accounted for approximately 8% of pediatric patients at the R3-MMU.

Finally, we performed a univariate logistic regression to attempt to identify patient factors independently associated with mortality in the pediatric population cared for at the R3-MMU the results of which are summarized in Table 4. Interestingly, female sex, injury severity score (ISS), temperature on presentation, international normalized ratio, base deficit, GCS and battle-related injury were all associated with in-hospital mortality ($p < 0.05$). Conversely, blast injury, initial cardiorespiratory vitals, partial pressure of carbon dioxide, hematocrit and number of systems affected were not significantly associated with in-hospital death in our analysis. These data suggest that factors other than physiologic status may have played a role in a patient's death.

Table 1. Demographic characteristics of patients younger than 18 years treated at the Role 3 Multinational Medical Unit, $n = 263$

Characteristic	No. (%)*
Sex	
Male	215 (82)
Female	48 (18)
Injury	
Battle injury	162 (62)
Non-battle injury	101 (38)
Age, yr	
0-2	20 (8)
3-5	55 (21)
6-8	53 (20)
9-11	59 (22)
12-14	51 (19)
15-17	25 (10)
Mean	9
Median	9
Range	3 mo to 17 yr

*Unless otherwise indicated.

Table 2. Mechanism, classification and severity of injuries

Injuries	No. (%)	Mean
Mechanism		
Blast	111 (42)	—
GSW	45 (17)	—
MVC	42 (16)	—
Fall	22 (8)	—
Burn	11 (4)	—
Other	32 (12)	—
Classification		
Penetrating	140 (53)	—
Blunt	71 (27)	—
Burns	25 (10)	—
Mixed	27 (10)	—
Patient characteristics		
ISS		12.3
1-14	171 (65)	
> 15	92 (35)	
GCS score		10.7
3-8	96 (36)	
9-12	14 (5)	
13-15	153 (58)	
Base deficit	—	-4.8
INR	—	1.3

GCS = Glasgow Coma Scale; GSW = gunshot wound; INR = international normalized ratio; ISS = injury severity score; MVC = motor vehicle collision.

DISCUSSION

The data presented in this paper further confirm the fact that pediatric casualties are commonly encountered in a modern field hospital during combat operations.⁵⁻⁹ Many pediatric patients were eligible for care at the R3-MMU by meeting the criteria of a battle injury or exceeding the capabilities of the Afghan local national facilities. Of this population, more than one-quarter were children younger than 6 years. Resuscitating these patients can require special training and expertise, and the presence of a pediatric intensivist and nurses with pediatric training at the R3-MMU was invaluable in these circumstances. Many NATO military forces, including the CAF, do not employ pediatricians or pediatric subspecialists, as their primary mission is to care for the deployed NATO Forces themselves as opposed to the civilian population. Therefore, deployed health care workers must be comfortable practising outside their normal comfort zone. One option for consideration in future missions where pediatric intensive care physicians are not available is to use telemedicine capabilities for assistance in caring for these pediatric casualties.

Explosive blast injuries were by far the most prevalent mechanism of injury in the pediatric population that we studied. This finding can be attributed to the ubiquitous use of IEDs by Taliban insurgents, as well as the prevalence of unexploded munitions in the country. Gunshot wounds in children were also encountered, though with much less frequency than wounds from explosions. Consistent with these findings, most pediatric patients had penetrating injuries. However, non-battle injuries from MVCs, falls and burns were also encountered. In Afghanistan, automotive safety devices are often not available or not used, road conditions are often poor, and many vehicles are overcrowded. As a result, single-family MVCs would often lead to multiple pediatric casualties. Falls were also a common occurrence, often owing to the tradition of sleeping on the roofs of houses during the summer months.¹⁰ Finally, a spike in burn injuries was encountered during the winter months from the use of indoor kerosene heaters. The Kandahar City fire chief initiated a burn prevention program that was successful until he was targeted by a Taliban attack. This illustrates

another level of complexity to trauma care and prevention in combat environments.

In our study population, more than one-third of pediatric casualties were severely injured, with an ISS greater than 15. A similar proportion had injuries resulting in a GCS score of 8 or lower, suggesting severe head injury or hemodynamic compromise. Admittedly, there is selection bias in this population, as critically injured children were more likely to be eligible for treatment at the R3-MMU. However, treating critically injured pediatric trauma patients can be a daunting experience for all members of the health care team, especially given that many normally practise in adult centres. The presence of a pediatric subspecialist was certainly valuable in the treatment of these severely injured children, and although not all NATO countries employ physicians with this training, having access to this expertise via telemedicine capability may be worthy of consideration in future missions. The inclusion of pediatric staff by the USNMC was the result of feedback from earlier missions.^{5,11}

Pediatric trauma patients often required considerable resources for their care, including critical care interventions such as mechanical ventilation and ward care. Members of the patient's family would also be allowed to stay with them and had to be fed and sheltered at the R3-MMU. As a result, care of this population also presented logistical challenges. Pediatric equipment often had to be specifically stocked or improvised, and family needs had to be met. Despite these challenges, nearly half of the patients were discharged directly home. The arrangement of follow-up care was also possible in many cases. A large proportion (38%) were transferred to the

Table 3: Hospital stay and discharge status

Characteristic	No. [range] or no. (%)
LOS, d	5.3 [0- 43]
ICU LOS, d	2.1 [0-23]
Ventilator, d	1.3 [0-22]
Discharge status	
Home	123 (47)
Local (Afghan) hospital	99 (38)
Other NATO hospital	21 (8)
Death	20 (8)

ICU = intensive care unit; LOS = length of stay; NATO = North Atlantic Treaty Organization.

Table 4. Association between patient factors and mortality

Factor	Group, mean ± SD		p value
	Survivors	Nonsurvivors	
Female sex	0.16 ± 0.37	0.45 ± 0.51	0.02
ISS	11.40 ± 8.00	23.20 ± 15.40	0.003
Temperature	36.80 ± 1.00	35.80 ± 1.00	0.01
INR	1.30 ± 0.40	2.30 ± 1.60	0.047
Base deficit	-4.40 ± 4.60	-11.00 ± 5.00	< 0.001
GCS	11.00 ± 5.00	7.00 ± 5.00	0.001
Battle injury	0.63 ± 0.48	0.40 ± 0.50	0.04
Explosive injury	0.43 ± 0.50	0.30 ± 0.47	0.25
Heart rate, bpm	116.00 ± 28.00	123.00 ± 46.00	0.50
Systolic blood pressure, mm Hg	116.00 ± 20.00	105.00 ± 35.00	0.20
Respiratory rate, bpm	27.00 ± 10.00	22.00 ± 8.00	0.20
SpO2	99.00 ± 3.00	92.00 ± 24.00	0.25
Hematocrit	32.00 ± 6.00	33.00 ± 10.00	0.80
pCO2	46.00 ± 34.00	52.00 ± 16.00	0.20
No. systems injured	3.90 ± 2.70	3.60 ± 2.80	0.60

bpm = beats or breaths/min; GCS = Glasgow Coma Scale; ISS = injury severity score; INR = international normalized ratio; pCO2 = pressure of carbon dioxide; SD = standard deviation; SpO2 = peripheral capillary oxygen saturation.

local hospital, where resources were more limited and nighttime care was carried out by the patient's family. The long-term outcome data on these patients, including 30-day mortality, were not consistently available for analysis.

The results of the univariate logistic regression provide some evidence that mortality was a result of multiple factors. Pediatric patients who died in hospital often displayed evidence of the "lethal triad"; they were often found to be cold, coagulopathic and acidemic. In our analysis they were also found to be more severely injured (higher ISS) and have a lower GCS score. These data support the evidence of the high acuity of pediatric patients seen at the R3-MMU and potentially offer further support for pediatric critical care resources and expertise in these missions. Interestingly, we found female sex to be independently associated with mortality. This finding is consistent with those of other reports on pediatric trauma seen in combat support hospitals in Iraq and Afghanistan. There is no clear explanation for this discrepancy, though some have surmised that it may be attributable to cultural differences in the relative value placed on male versus female offspring when seeking medical attention. Another interesting finding was that battle injury, but not blast injury per se, was also associated with mortality. We can only speculate as to the reasons for this, but it may be owing to a factor such as increased medical evacuation times because of tactical considerations. Taken together as a whole, the data presented here illustrate the substantial challenges encountered and resources necessary for providing pediatric patient care in a modern combat support hospital.

Limitations

This study was conducted using data from the JTTR and, therefore, we were able to report only on pediatric patients admitted for traumatic injuries. There was also a nontrauma pediatric patient population with severe illness who received care at the hospital who were not captured in our data set. Therefore, the pediatric population described here is likely an underrepresentation of the overall patient caseload. Further, the role of the R3-MMU was to provide short-term specialty care before returning pediatric patients to the Afghan national health care system. As a result, long-term outcome measures of mortality and hospital readmission were not consistently available. Finally, as not all pediatric trauma patients were eligible for care at the R3-MMU, there is an admitted selection bias in that more severely injured patients and patients with head injuries were more likely to be transferred and therefore entered into the JTTR.

CONCLUSION

We have described the pediatric patient burden seen at a modern military field hospital during combat operations. The children seen at the R3-MMU had often experienced severe injuries and required subspecialist care. This population constituted a large portion of the patient load and required substantial specialized care and resources. Modern military health care elements must balance providing care for vulnerable civilian patient populations with the risk of creating dependence on foreign health care resources.

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Competing interests: None declared.

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