Injury, Int. J. Care Injured 43 (2012) 2078–2082

Contents lists available at SciVerse ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Resuscitation volume in paediatric non-haemorrhagic blunt trauma

Abdullah Al-Sharif [a,b], Varsha Thakur [a], Sami Al-Farsi [a,c], Ram N. Singh [a], Alik Kornecki [a], Jamie A. Seabrook [a,d], Douglas D. Fraser [a,d,e,f,g,h,*]

[a] Paediatric Critical Care Medicine, University of Western Ontario, London, ON, Canada
[b] Paediatric Critical Care Medicine, King Fahad Medical City, Riyadh, Saudi Arabia
[c] Paediatric Emergency Medicine, Royal Hospital, Muscat, Oman
[d] Children's Health Research Institute, London, ON, Canada
[e] Centre for Critical Illness Research, London, ON, Canada
[f] Physiology/Pharmacology, University of Western Ontario, London, ON, Canada
[g] Clinical Neurological Sciences, University of Western Ontario, London, ON, Canada
[h] Translational Research Centre, London, ON, Canada[i]

ARTICLE INFO

Article history:
Accepted 13 January 2012

Keywords:
Trauma
Children
Resuscitation
Volume
Crystalloid
Complications
Ascites
Effusion

ABSTRACT

Introduction: Trauma is a major cause of paediatric morbidity and mortality, yet knowledge of fluid resuscitation is limited. Our objectives were to determine current practises in resuscitation volume (RV) administered to paediatric non-haemorrhagic (NH) blunt trauma patients and to identify fluid related complications.

Methods: We examined data from 139 trauma patients 1–17 years of age with an injury severity score ≥12 resuscitated at a Trauma-designated Children's Hospital. Patients were separated into discreet groups based on ATLS age-dependent vital functions: toddler/preschooler (1–5 years), school age (6–12 years) and adolescent (13–17 years).

Results: The median RV (total fluid intake − maintenance fluid intake) in ml/kg over the first 24 h from the time of trauma by age was: 24 (IQR = 19–47; 1–5 years); 26 (IQR = 15–36; 6–12 years); and 22 (IQR = 14–42; 13–17 years). The differences in RV/kg/24 h following NH trauma was not significantly different between age groups ($p = 0.41$). Urine output over the 24 h ranged from 2.5 (IQR = 1.9–3.3; lower age group) to 1.8 (IQR = 1.2–2.4; upper age group) ml/kg/h; greater than the ATLS recommended age-dependent targets. Haematocrit was the only significant independent predictor of RV/kg/24 h ($p < 0.001$). Fluid-related complications attributable to RV were identified in 12% ($n = 17/139$) of patients, and included ascites (8%; $n = 11/139$) and/or pleural effusion(s) (9%; $n = 13/139$). Patients with fluid-related complications received significantly more RV in ml/kg/24 h (42, IQR = 27–76) than those without complications (22, IQR = 14–36; $p = 0.001$).

Conclusions: The range of median RV administered to paediatric NH blunt trauma patients with ISS ≥ 12 was 22–26 ml/kg/24 h. The RV administered was excessive based on high urine outputs and the presence of fluid-related complications. Further evaluation of RV triggers and endpoints used by paediatric traumatologists is required.

Introduction:

Trauma, the leading cause of paediatric morbidity and mortality,[1,2] requires rapid replacement of circulating volume.[3] Restoration of intravascular volume minimises tissue hypoperfusion and inflammatory responses to trauma. Resuscitation volume (RV) is guided by improvements in vital signs, perfusion, urine output and acid/base status. However, vital signs and tissue hypoperfusion are affected by factors other than hypovolemia such as the inflammatory response initiated by the injury.[4] Whilst delays in fluid resuscitation can increase morbidity and mortality,[5] administration of excessive RV may result in fluid-related complications and worsen outcome in some trauma patients.[6]

Paediatric trauma is often managed conservatively with fluid resuscitation, supportive measures and continuous monitoring in an appropriate hospital setting. The required RV in paediatric trauma patients, however, is unclear. Prior to initiating a prospective RV clinical trial, we felt it necessary to understand current RV practises in paediatric trauma resuscitation. As most

* Corresponding author at: Paediatric Critical Care Medicine, Room #C2-846, Children's Hospital, London Health Sciences Centre, 800 Commissioners Road East, London, Ontario, Canada N6C 2V5. Tel.: +1 519 685 8386; fax: +1 519 685 8186.
E-mail addresses: fraserd@lhsc.on.ca, douglas.fraser@lhsc.on.ca (D.D. Fraser).
[i] http://www.translationalresearch.ca.

0020–1383/$ – see front matter
doi:10.1016/j.injury.2012.01.012

paediatric trauma does not require surgical intervention,[7,8] we focused on non-haemorrhagic (NH) blunt trauma. Thus, the objectives of this study were to (1) determine the volume of fluid provided to paediatric NH blunt trauma patients and (2) document complications associated with fluid administration. A better understanding of RV following trauma will help optimise fluid requirements to lessen hypoperfusion and over-resuscitation complications.

Materials and methods

This study was approved by the Health Sciences Research Ethics Board at The University of Western Ontario. The Children's Hospital, London Health Sciences Centre, is a designated Paediatric Trauma Centre with a 12 bed paediatric critical care unit (PCCU). Extensive data on each patient are entered into a provincially mandated trauma database and injury severity score (ISS) calculated by a single injury data specialist. All paediatric trauma patients resuscitated over a five-year period were identified via the trauma database and cross-checked with hospital admission records. We included all NH trauma patients with an ISS $\geq$ 12 between the ages 1 and 17 years. NH trauma was defined as any trauma patient who (1) did not require blood transfusion or surgical interventions to achieve haemodynamic stability during the first 24 h of admission, and (2) did not have evidence of bleeding on either clinical examination or imaging. Solid organ injuries were considered NH in the absence of haemodynamic instability, blood transfusion, haemothorax and hemoperitoneum. All trauma patients included in this study had nothing by mouth over the first 24 h.

Data collected included patient demographics, injury data, types and volumes of fluids administered, urine output and imaging studies. Laboratory data from trauma blood panels were collected and included complete blood count, electrolytes, biochemistry and coagulation studies. The reported laboratory values represent repeat blood work from the trauma patients after admission to the PCCU, a time point when all or most of the RV had been administered. Radiology reports were evaluated for any evidence of significant fluid overload over 48 h after the trauma, including pleural effusion and/or ascites (low-attenuation fluid of 0–15 HU on CT without organ laceration/perforation).[9] As vital functions change with development, and consistent with ATLS (8th ed.; Table 10-4),[3] our patient population was divided into three age groups: toddler/preschool (1–5 years); school age (6–12 years); and adolescent (13–17 years).

Fluid administered (ml/kg) for the first 24 h after the trauma was obtained from the scene, in referring hospitals and during admission to Children's Hospital. Resuscitation volume (RV; ml/kg/24 h) was calculated as the difference in fluid between the total fluid intake (TFI) and the calculated maintenance fluid intake (MFI). MFI over 24 h were calculated using the standard formula $[(100\ \text{ml} \times 0\text{–}10\ \text{kg}) + (50\ \text{ml} \times 10\text{–}20\ \text{kg}) + (20\ \text{ml/kg} \times 20+\ \text{kg})]$ as outlined by Holliday and Segar.[10] The type of fluid used for resuscitation was also recorded. The volume of mannitol or hypertonic saline given for the treatment of cerebral oedema in patients with severe traumatic brain injury (TBI) was typically minimal in the first 24 h after the trauma and therefore not incorporated in the calculation for RV.

Data were analysed in PASW Statistics, version 18.0. Since values of the outcome variables were not normally distributed within each of the three age groups, skewed continuous variables were expressed as median and interquartile range (IQR). Categorical data were reported as percentages. Kruskal–Wallis one way analysis of variance on ranks and the Dunn's post-test were used to compare median differences between the groups. Graphed data was presented as box plots incorporating median, IQR, and both 90th and 10th percentiles (whiskers). As age did not correlate with RV, a Pearson correlation coefficient was used to assess the degree of linear relationship between two normally distributed continuous variables. Several skewed variables now became normally distributed once age was no longer a factor. A multiple regression was then computed between RV as the outcome variable and ISS, haematocrit, platelets, chloride, base excess and INR as predictor variables. Only those variables that had a significant correlation with the outcome in the univariate analysis were included in the model. p values <0.05 were considered statistically significant.

Results

A total of 418 trauma patient charts were reviewed with surgical management required in 19% (n = 81/418) and an overall mortality rate of 6% (n = 24/418). Of the 418 patients, 139 met criteria for inclusion in this study. The patient demographics, mechanisms of injuries and primary injuries are listed in Table 1. The majority of trauma patients were male and the most common mechanism of injury was motor vehicle collisions (MVC). Traumatic brain injury (TBI) was the most common primary injury. Delayed surgical interventions (those within 24 h of admission) were the most common exclusion criterion (Table 2).

Separated into three discreet groups based on age-dependent vital functions,[3] the median weights in kg were 17 (IQR = 15–21; n = 9/139) for toddler/preschool, 32 (IQR = 30–40; n = 48/139) for school age, and 61 (IQR = 55–70; n = 82/139) for adolescents. The median ISS for the different groups were as follows: toddler/preschool 20 (IQR = 17–28); school age 17 (IQR = 16–30); and adolescent 25 (IQR = 17–35). A significant difference in ISS was found only between the school age and adolescent groups (Fig. 1A; p = 0.04). The median TFI in ml/kg/24 h by the different groups were as follows: toddler/preschool 115 (IQR = 88–126); school age 80 (IQR = 63–98); and adolescent 63 (IQR = 53–80). A significant difference between groups was determined (Fig. 1B; $p < 0.001$). Once corrected for MFI, the median RV in ml/kg over the first 24 h and separated by age was: toddler/preschool 24 (IQR = 19–47); school age 26 (IQR = 15–36); and adolescent 22 (IQR = 14–42). The differences in RV in the first 24 h following NH trauma was not different between age groups (Fig. 1C; p = 0.66). The median urine output over 24 h ranged from 2.5 (IQR = 1.9–3.3; toddler-preschool) to 1.8 (IQR = 1.2–2.4; adolescent) ml/kg/h and did not differ between the three age groups (p = 0.12; Fig. 1D).

Table 1
Patient demographics, mechanisms of injury and primary injury (n = 139).

Patient demographics	
Male:female	87 (63%):52 (37%)
Median age in years	14 (IQR = 10–16)
Median weight in kg	54 (IQR = 33–65)
Median ISS	24 (IQR = 16–30)
Mechanisms of injury	
Motor vehicle collisions	71 (51%)
Falls from heights	19 (14%)
Pedestrians vs. vehicles	15 (11%)
Recreational vehicles	10 (7%)
Pedal bikes	10 (7%)
Sports	6 (4%)
Others	8 (6%)
Primary injury	
Traumatic brain injury	66 (47%)
Splenic injury	27 (19%)
Orthopaedic injuries	15 (11%)
Liver injury	12 (9%)
Thoracic injuries	7 (5%)
Facial injuries	7 (5%)
Renal injury	5 (4%)