Pitfalls in paediatric trauma resuscitation

Paediatric trauma resuscitation often follows the “little adults” axiom or the corollary, “not little adults”. In essence both are probably true in different domains. Knowing when to treat kids like little adults and when not to, can help avoid pitfalls.

**Kids ARE little adults**

Haemorrhage and traumatic brain injury (TBI) are the leading causes of death in paediatric trauma (1,2). The same is found in adults.

**Severe TBI** mortality and functional outcome is worsened by even a short period of hypotension (3). Early hypotension, defined as **SBP < 5th percentile for age** in the field and/or ED, was a better predictor of poor outcome than delayed hypotension or the use of SBP < 90 mmHg. (3) Hypoxia and hypercarbia are also associated with worsened outcomes (PEGAGUS study,4).

As GCS is harder to measure in kids and as practitioners are often unfamiliar and uncomfortable with paediatric trauma resuscitation this can lead to cognitive dissonance, e.g. knowing the child needs a RSI and neuroprotection but not having the skills so disbelieving the clinical signs or convincing oneself the patient does not have severity of injury requiring an intervention. Paediatric trauma resuscitation can also be associated with errors of omission, where interventions are not performed despite being indicated.

It is critical to TBI outcomes in kids that hypoxia is avoided, blood pressure is maintained and hypercarbia is avoided. Paediatric trauma resuscitation can lead to cognitive overload. To assist cognitive offloading in these circumstances use:

1. Paediatric Trauma Checklists (from Children’s National Medical Center, 5)
2. Paediatric RSI checklists and reference cards (6). Checklists for high risk procedures are important in not only cognitive offloading but also ensuring uniformity of high performance and familiarity of process for infrequent attendees to the ED resuscitation room. Weight-based dosing cheatsheets are also vital in avoiding under or overdosing critical medications or fluids.
Haemorrhage

Children bleed the same stuff as adults. The principles of damage control resuscitation (DCR) and haemostat resuscitation (HR) can be applied in kids. DCR involves early blood component therapy, minimising crystalloid, avoiding over-resuscitation/supranormal MAP combined with HR and rapid surgical control of bleeding where needed.

Central to this are blood products ratios. Best evidence in adults is 1:1:1 (PROPPR, 7) but remains unclear what ratios provide long-term mortality benefit. The optimal ratio in kids remains elusive (8-10). When a child is critically bleeding early balanced transfusion is required with repeated coagulation monitoring and goal-directed transfusion. Prehospital crystalloid volume replacement is associated with increased transfusion need, coagulopathy and trend towards increased mortality and MOF (11).

Warm fresh whole blood is the ideal resuscitation fluid as it contains all the components necessary without the need for preservatives or preparation time. This hasn't been studied in paediatric trauma. However in a paediatric cardiac surgery study whole blood (24-48hrs old, stored 4°C) v products resulted in less post-op blood loss.

Predefined MTP is common in adult trauma but surprisingly rarely described (only 2 studies) in paediatric trauma and remains controversial (12,13).

Predefined Paediatric MTP (14) shown above guided by viscoelastography allows targeted resuscitation as in adults and should be considered the standard to aim for in paediatric fluid resuscitation.

Adjuvant haemostatic agents have not been rigorously assessed in kids. Military data from Afghanistan demonstrated decreased mortality in severe paediatric trauma administered TXA (15). Dosage TXA - 15mg/kg over 1 hour, followed by 2mg/kg/hr for 8 hours under 3 hours from time of injury.

Acute traumatic coagulopathy (ATC) carries a high incidence and mortality in severe adult trauma. It is at least as prevalent in paediatric trauma patients. (16-18). ATC is caused by tissue factor release, activation of protein C and hyperfibrinolysis.
Acute Traumatic Coagulopathy

Coagulation monitoring follows traditional plasma-based clot tests (PT, aPTT, INR, fibrinogen, platelet count). These tests have poor clinical correlation and don’t inform the clinician as to what’s happening contemporaneously. Viscoelastography such as TEG/ROTEM analyse viscoelastic properties of the whole blood in real-time, reflecting the entire haemostatic process. Age specific values do exist for TEG/ROTEM. This allows age-specific targeted goal-directed therapy as in adults.

Risks of transfusion do exist as in adults: largely febrile non-haemolytic reaction due to ABO incompatibility. Transfusions can cause volume overload, electrolyte disturbance—hypocalcaemia, hyperkalaemia and dilutional coagulopathy if non-balanced. Predefined MTP in adults is associated with reduced MOF, infection and ventilator days in adults and lower mortality (19).

Physiology- SHOCK

Shock index (SI) (heart rate/systolic blood pressure)>0.9 predicts mortality in adult trauma patients. Paediatric age-adjusted SI in blunt trauma also predicts intra-abdominal injury requiring transfusion, and those that are at highest risk of death (20).

Serum lactate as a prehospital or ED tool to assess severity of injury or indeed occult shock in trauma has some merit in paediatrics but like in adults does lack sensitivity and specificity. Lactate over 4.7 mmol/L is strongly suggestive of severe injury, while lactate below 2.0 mmol/L is reassuring for not having injury. Lactates between 2.0 and 4.7 mmol/L remain indeterminate in predictive potential for injury or outcomes (21).

Interventions

In the resuscitation room, appropriate interventions need to be performed rapidly as in adults. Large vascular access, IO, finger thoracostomy are such examples. Large bore vascular access is preferable as in adults. An often overlooked aspect in paediatrics is vascular access. Large bore access above the diaphragm is ideal. Cannulation of the external jugular vein is rapidly achievable (22).
Look for the ‘blue dot’ appearance of the EJV.
Resuscitative thoracotomy in penetrating trauma is indicated along the same guidelines as adults. Blunt traumatic cardiac arrest without SOL in ED has uniformly been unsalvageable in paediatrics and of questionable benefit outside of pericardial tamponade (23,24).

**Logistics**

Resuscitation in trauma should be a like a F1 pit-lane. Each team member has a specific role and works simultaneously with clear leadership. This has to be practiced and trained for using in-situ simulation and case review/debrief/governance. PTCs can learn from high performance adult MTCs. Critical decision points and triggers are essential as are team leadership and rapid decision making. Major paediatric trauma is emotive and only essential staff only should be in the resuscitation bay. During resuscitation kids should be properly exposed to identify injuries and covered up as soon as practicable. Paediatric trauma resuscitation would likely benefit from stress inoculation training of staff to improve the function of the trauma team under pressure (25) and cross-pollination with adult trained emergency physicians.

**Analgesia**

Acute pain causes a stress response, resulting in physiological, biochemical and behavioural changes in adults and kids. Although paediatric analgesia in the prehospital arena and ED has improved, there remains a challenge with oligoanalgesia in trauma. Catecholamine effects of pain may be deleterious in severe trauma. Behavioural changes can transform into PTSD from a single incident. Children are often given 50% of weight-based equivalent compared to adults (26). Oligoanalgesia is multifactorial. Poor clinician judgement of pain by both clinicians and parents and lack of comfort of clinicians treating kids plays a role. In a study of 203 patients with moderate to severe trauma (ISS>12) at a PTC given analgesia during the primary and secondary survey in ED only 32% received analgesia. Presence of parents, MVC, direct arrival to PTC and TTA were associated with increased likelihood of analgesia (27). Subdissociative analgesic doses of ketamine have been used by HEMS physicians (0.1-0.25mg/Kg i.v.) for years and is increasingly being used in ED. Intra-nasal fentanyl has transformed prehosptial and ED analgesia of paediatric fractures and burns. Regional anaesthesia and PCA (where possible) should also be employed where indicated.

**Kids are NOT little adults**

**Appreciation of Anatomy**

Kids are at higher risk of TBI given relatively larger head, less fat, more exposed liver and spleen, pliable skeleton allowing transmission of force internally.

**Mechanism**

Motor vehicle trauma-occupant/pedestrian and falls make up the vast majority of injuries with high isolated TBI incidence in younger kids. There are lower levels of penetrating trauma and assaults in kids compared with adults.

**Physiology**

Clinical signs of hypovolaemia may be masked by physiological reserve and compensation. Maintain near-normal BP until a loss of >20% circulating blood volume. A narrow pulse pressure is a more sensitive sign than tachycardia or systolic hypotension. Lactic acidosis in the context of trauma demonstrates hypoperfusion or may be due to severe hypoxia.
Higher metabolic rate and oxygen consumption means that kids will desaturate faster during the apnoea of RSI or will become hypoxic faster with any acquired V/Q mismatch from trauma. Higher BSA to weight means kids become hypothermic faster.

**Psychosocial**

Kids’ behavior regresses in severe trauma by around 5 years. Trauma teams need to adjust behavior accordingly and be understanding and cognitive of this. Parents should not be precluded from the resuscitation room both for child’s benefit and theirs.

**Radiology**

Kids should have tailored CT scanning based on clinical findings and suspicion. Imaging dosing should follow ALARA (as low as reasonably achievable) principles where possible (28).

In a recent review of 157 paediatric trauma patients with a mean Injury Severity Score of 22.5 (range 12-75), 133 patients received at least one CT scan. The mean number of scans per patient was 2.6 (range 0-16). Most scans resulted in no further action (56%) or additional imaging (32%). A decision to perform a procedure (2%), surgery (8%), or withdrawal of life support (2%) was less common. The average dose per patient was 13.5mSv. (29).

eFAST is more likely to be performed in kids on adult MTC or mixed EDs. Free fluid in the pelvis can be physiological in kids. Data are conflicting on the role for eFAST in paediatric resuscitation. Some argue free fluid in the LUQ/RUQ is pathological (30) and has higher sensitivity/specificity for intra-abdominal pathology. Others argue that sensitivity and NPV is not high enough to exclude pathology (28,30). In these instances based on clinical assessment CT is the imaging modality of choice. It’s likely the truth is somewhere in the middle ground.

**Non-operative Critical Care**

Solid organ abdominal (spleen and liver) trauma in kids are more likely to undergo non-operative management compared with adults. Increasingly the adult trauma management is following suit with non-operative interventional management and high level critical care.

**Trauma Deaths and Debrief**

Death in pediatric trauma is more likely to be associated with higher psychological impact on the trauma team than in adults. It is important that the trauma centre has a process for immediate and more formal review and debrief involving multidisciplinary members. All team members were once children and often have their own children, sometimes of the same age to the child that has just died. It is important that the trauma team learns to cope with this and always improve so that future cases can get the best possible chance of survival.
References


15. Eckert MJ1, Werten TM, Tyner SD et al. Tranexamic acid administration to pediatric trauma patients in a combat setting: the pediatric trauma and tranexamic acid study (PED-TRAX). J Trauma Acute Care Surg. 2014 Dec;77(6):852-8


28. https://www.rcr.ac.uk/publication/paediatric-trauma-protocols


Reference Abstracts

The effect of hypotension and hypoxia on children with severe head injuries.
Pigula FA1, Wald SL, Shackford SR, Vane DW.

Abstract
Survival of children (< 17 years) with severe head injuries (Glasgow Coma Scale [GCS] score < 8) has been shown to be better than that of adults. The addition of hypotension (HT) or hypoxia (H) has a deleterious effect on outcome in adults but no information is currently available about their effects in children. Over a 5-year period, 58 children with GCS scores < 8 were admitted and prospectively evaluated at this institution. Patients were divided into two groups on the basis of systolic blood pressure (SBP) and arterial blood gasses. Patients exhibiting HT, defined as a SBP < 90 mm Hg, and patients demonstrating H with a PaO2 < 60 mm Hg were compared with normoxic, normotensive children. Survival was increased fourfold in patients with neither H nor HT as compared with children with either H or HT (P < .001). To validate these observations we reviewed the data from the National Pediatric Trauma Registry for similar patients and included our cohort in the analysis. In total, 509 children had sufficient data for analysis and were studied. Hypoxia alone was not associated with increased mortality in normotensive patients (P = .34). Hypotension significantly increased mortality in these children even without concomitant H (P < .00001). If both HT and H were found together, mortality was only slightly increased over those children with HT alone (P = .056). These data confirm that HT with or without H causes significantly increased mortality in head-injured children to those levels normally found in adults (P = .9), alleviating any age-related protective mechanisms normally afforded.

Resuscitative thoracotomy for pediatric trauma in Illinois, 1999 to 2009.
Nicolson NG1, Schwulst S2, Esposito TA3, Crandall ML2.

BACKGROUND:
Outcomes in adults who undergo resuscitative thoracotomy are poor. Few studies have examined the procedure's use in pediatric trauma.

METHODS:
The Illinois State Trauma Registry was queried for thoracotomy performed in the emergency department from 1999 to 2009, for patients aged 0 to 15. Injury mechanism, vital signs, and mortality were examined while controlling for injury severity.

RESULTS:
Resuscitative thoracotomy was infrequently performed in pediatric trauma (n = 25; 2.3/year). Most patients had suffered penetrating injury. Patients who underwent resuscitative thoracotomy were in extremis, with only 17% demonstrating signs of life upon presentation. Although 6 patients (24%) survived initially, only 2 (8%) survived to hospital discharge.
CONCLUSIONS:
Resuscitative thoracotomy was rarely performed in children in Illinois emergency departments. Survival is low for thoracotomy in the emergency department, but some patients who presented with penetrating injuries did have positive outcomes, supporting a continued role for the procedure in select cases.


**Pediatric emergency department thoracotomy: a large case series and systematic review.**

BACKGROUND/PURPOSE:
The emergency department thoracotomy (EDT) is rarely utilized in children, and is thus difficult to identify survival factors. We reviewed our experience and performed a systematic review of reports of EDT in pediatric patients.

METHODS:
Patients age ≤18 years who received an EDT from 1991 to 2012 at our institution and all published case series were reviewed. Data analyzed include age, sex, mechanism of injury (MOI), injury patterns, presence of vital signs (VS) or signs of life (SOL) in the field/ED, return of spontaneous circulation (ROSC), and survival.

RESULTS:
A total of 252 patients were analyzed. 84% were male. 51% sustained penetrating injuries, and median age was 15 years. Upon arrival, 17% had VS, and 35% had SOL. After EDT, 30% experienced ROSC. The survival rate was 1.6% for blunt trauma, 10.2% for penetrating injuries, and 6.0% overall.

CONCLUSION:
Survival of pediatric patients following EDT is comparable to recent analyses in adults. Children who **sustain blunt injury and are without SOL** have been uniformly **unsalvageable.** Children who **sustain penetrating trauma** and **have SOL or are without SOL** for a short time prior to arrival have been salvageable. There are no reported EDT survivors less than 14 years of age following blunt injury.


**Sub-dissociative dose intranasal ketamine for limb injury pain in children in the emergency department: a pilot study.**
Yeaman F, Oakley E, Meek R, Graudins A.

OBJECTIVE:
The present study aims to conduct a pilot study examining the effectiveness of intranasal (IN) ketamine as an analgesic for children in the ED.

**METHODS:**
The present study used an observational study on a convenience sample of paediatric ED patients aged 3-13 years, with moderate to severe (≥6/10) pain from isolated limb injury. IN ketamine was administered at enrolment, with a supplementary dose after 15 min, if required. Primary outcome was change in median pain rating at 30 min. Secondary outcomes included change in median pain rating at 60 min, patient/parent satisfaction, need for additional analgesia and adverse events being reported.

**RESULTS:**
For the 28 children included in the primary analysis, median age was 9 years (interquartile range [IQR] 6-10). Twenty-three (82.1%) were male. Eighteen (64%) received only one dose of IN ketamine (mean dose 0.84 mg/kg), whereas 10 (36%) required a second dose at 15 min (mean for second dose 0.54 mg/kg). The total mean dose for all patients was 1.0 mg/kg (95% CI: 0.92-1.14). The median pain rating decreased from 74.5 mm (IQR 60-85) to 30 mm (IQR 12-51.5) at 30 min (P < 0.001, Mann-Whitney). For the 24 children who contributed data at 60 min, the median pain rating was 25 mm (IQR 4-44). Twenty (83%) subjects were satisfied with their analgesia. Eight (33%) were given additional opioid analgesia and the 28 reported adverse events were all transient and mild.

**CONCLUSIONS:**
In this population, an average dose of 1.0 mg/kg IN ketamine provided adequate analgesia by 30 min for most patients.


**Pediatric specific shock index accurately identifies severely injured children.**
Acker SN1, Ross JT2, Partrick DA3, Tong S4, Bensard DD5.

**INTRODUCTION:**
Shock index (SI) (heart rate/systolic blood pressure)>0.9 predicts mortality in adult trauma patients. We hypothesized that age adjusted SI could more accurately predict outcomes in children.

**METHODS:**
Retrospective review of children age 4-16 years admitted to two trauma centers between 1/07 and 6/13 following blunt trauma with an injury severity score (ISS)>15 was performed. We evaluated the ability of SI>0.9 at emergency department presentation and elevated shock index, pediatric age adjusted (SIPA) to predict outcomes. SIPA was defined by
maximum normal HR and minimum normal SBP by age. Cut-offs included SI>1.22 (age 4-6), >1.0 (7-12), and >0.9 (13-16).

RESULTS:
Among 543 children, 50% of children had an SI>0.9 but this fell to 28% using age adjusted SI (SIPA). SIPA demonstrated improved discrimination of severe injury relative to SI: ISS>30: 37% vs 26%; blood transfusion within the first 24 hours: 27% vs 20%; Grade III liver/spleen laceration requiring blood transfusion: 41% vs 26%; and in-hospital mortality: 11% vs 7%.

CONCLUSION:
A pediatric specific shock index (SIPA) more accurately identifies children who are most severely injured, have intraabdominal injury requiring transfusion, and are at highest risk of death when compared to shock index unadjusted for age.


A pediatric specific shock index in combination with GMS identifies children with life threatening or severe traumatic brain injury.
Acker SN¹, Ross JT², Partrick DA³, Bensard DD⁴.

PURPOSE:
We have previously demonstrated that a shock index, pediatric age adjusted (SIPA) accurately identifies severely blunt injured children. We aimed to determine if SIPA could more accurately identify children with severe traumatic brain injury (TBI) than hypotension alone.

METHODS:
We performed subset analysis of those children with TBI among a cohort of children age 4-16 years with blunt trauma and injury severity score ≥15 from 1/07 to 6/13. We evaluated the ability of four markers to identify the most severely brain injured children. Markers included hypotension, elevated SIPA, abnormal GCS motor score (GMS), and elevated SIPA or abnormal GMS. We aimed to determine which of these four markers had the highest sensitivity in identifying severely injured children.

RESULTS:
Three hundred and ninety-two (392) children were included. Hypotension was present in 24 patients (6%); elevated SIPA in 106 (27 %), abnormal GMS in 172 (44%), and elevated SIPA or abnormal GMS in 206 (53%). All markers were able to accurately identify severely injured children with TBI. Elevated SIPA or abnormal GMS identified a greater percentage of patients with each of seven complications with higher sensitivity than each of the three other markers.

CONCLUSION:
Among blunt injured children with TBI, elevated SIPA or abnormal GMS identifies severely brain injured children.


**Utility of admission serum lactate in pediatric trauma.**

Ramanathan R¹, Parrish DW², Hartwich JE³, Haynes JH⁴.

**BACKGROUND/PURPOSE:**

Serum lactate measurement has a predictive value in adult trauma. To date, there has been no prospective analysis of the predictive value of admission serum lactate in pediatric trauma.

**METHODS:**

Admission serum lactate was prospectively measured over a two year period on all children under age 15 years who met trauma alert criteria at an urban Level 1 trauma center. Elevated serum lactate (>2.0 mmol/L) was correlated with Injury Severity Scores (ISS), injury types, and hospital outcomes.

**RESULTS:**

A total of 277 injured children with admission lactate measurements were evaluated. Patients with elevated lactate had higher mean ISS than those with normal lactate (12.8 vs. 5.1, p<0.01), and increased need for intubation, major procedures and ICU admission. Elevated lactate was associated with low specificity (54.4%), moderate sensitivity (86.7%) and high negative predictive value (94.5%) for detecting injury (ISS>15). Lactate measurements over 4.7 mmol/L were highly specific (95.8%) for injury.

**CONCLUSIONS:**

Elevated admission venous lactate level is associated with injury and outcomes, but lacks adequate sensitivity and specificity. Lactate over 4.7 mmol/L is strongly suggestive of severe injury, while lactate below 2.0 mmol/L is reassuring for not having injury. Lactates between 2.0 and 4.7 mmol/L remain indeterminate in predictive potential for injury or outcomes.


**Diagnostic accuracy of a single point-of-care prehospital serum lactate for predicting outcomes in pediatric trauma patients.**

Shah A¹, Guyette F, Suffoletto B, Schultz B, Quintero J, Predis E, King C.

**BACKGROUND:**

Preliminary evidence suggests that a single prehospital lactate level (pLA) improves prediction of morbidity and mortality in adult trauma patients independent of vital signs.
However, the value of pLA for pediatric trauma patients is unknown. Our objective was to determine whether pLA is associated with the need for critical care in pediatric trauma patients.

**METHODS:**
We conducted a cohort study of 217 patients transported by helicopter to a level I pediatric trauma center over 24 months. The primary outcome was the need for predefined critical care measures. Covariates included vital signs and Glasgow Coma Scale (GCS) scores documented by prehospital providers.

**RESULTS:**
Forty-one subjects required critical care. Abnormal prehospital vital signs were not associated with need for critical care. Overall, median pLA level for patients who required critical care was 2.1 mmol/L (interquartile range [IQR], 1.6-2.7 mmol/L) versus 1.7 mmol/L (IQR, 1.2-2.2 mmol/L) for those who did not (P = 0.01). In addition, there were 85 subjects who had normal vital signs and a normal GCS during transport. Of these, 11 (13%) required critical care. In the subset of patients with normal prehospital vital signs and GCS, median pLA level for patients who required critical care was 2.6 mmol/L (IQR, 1.8-2.6 mmol/L) versus 1.7 mmol/L (IQR, 1.0-2.1 mmol/L) for those who did not (P = 0.01).

**CONCLUSIONS:**
Prehospital lactate level was higher in pediatric trauma patients who required critical care, including those who had normal prehospital vital signs and GCS. In this cohort, lactate was an early identifier of children with severe traumatic injuries.
Limb injuries occurred in 65.0% of patients. In infants 81.4% of head injuries were isolated, compared with 46.5% in 11-15-year-old children. Thoracic injuries were associated with other injuries in 68.4%. The overall mortality rate was 3.7% (n = 893). Mortality decreased from 4.2% to 3.1%; this was most evident in non-isolated head injuries. It was low in isolated injuries: 1.5% (n = 293). In children aged 1-15 years the highest mortalities occurred in multiple injuries including head/thoracic (47.7%) and head/abdominal injuries (49.9%). Having a Glasgow Coma Scale of <15 on presentation to hospital was associated with a mortality of 16%.

CONCLUSIONS:
Differences in injury patterns and mortality exist between different age groups and high-risk injury patterns can be identified. With increasing age, a decline in the proportion of children with head injury and an increase in the proportion with limb injury were observed. This information is useful for directing ongoing care of severely injured children. Future analyses of the TARN database may help to evaluate the management of high-risk children and to identify the most effective care.


Radiation from CT scans in paediatric trauma patients: Indications, effective dose, and impact on surgical decisions.

Livingston MH1, Igric A, Vogt K, Parry N, Merritt NH.

OBJECTIVES:
The purpose of this study was to determine the effective dose of radiation due to computed tomography (CT) scans in paediatric trauma patients at a level 1 Canadian paediatric trauma centre. We also explored the indications and actions taken as a result of these scans.

PATIENTS AND METHODS:
We performed a retrospective review of paediatric trauma patients presenting to our centre from January 1, 2007 to December 31, 2008. All CT scans performed during the initial trauma resuscitation, hospital stay, and 6 months afterwards were included. Effective dose was calculated using the reported dose length product for each scan and conversion factors specific for body region and age of the patient.

RESULTS:
157 paediatric trauma patients were identified during the 2-year study period. Mean Injury Severity Score was 22.5 (range 12-75). 133 patients received at least one CT scan. The mean number of scans per patient was 2.6 (range 0-16). Most scans resulted in no further action (56%) or additional imaging (32%). A decision to perform a procedure (2%), surgery (8%), or withdrawal of life support (2%) was less common. The average dose per patient was 13.5mSv, which is 4.5 times the background radiation compared to the general population. CT head was the most commonly performed type of scan and was most likely to be repeated. CT body, defined as a scan of the chest, abdomen, and/or pelvis, was associated with the highest effective dose.
CONCLUSIONS:
1. CT is a significant source of radiation in paediatric trauma patients. Clinicians should carefully consider the indications for each scan, especially when performing non-resuscitation scans. There is a need for evidence-based treatment algorithms to assist clinicians in selecting appropriate imaging for patients with severe multisystem trauma.


The role of focused abdominal sonography for trauma (FAST) in pediatric trauma evaluation.

Scaife ER, Rollins MD, Barnhart DC, Downey EC, Black RE, Meyers RL, Stevens MH, Gordon S, Prince JS, Battaglia D, Fenton SJ, Plumb J, Metzger RR.

PURPOSE:
With increasing concerns about radiation exposure, we questioned whether a structured program of FAST might decrease CT use.

METHODS:
All pediatric trauma surgeons in our level 1 pediatric trauma center underwent formal FAST training. Children with potential abdominal trauma and no prior imaging were prospectively evaluated from 10/2/09 to 7/31/11. After physical exam and FAST, the surgeon declared whether the CT could be eliminated.

RESULTS:
Of 536 children who arrived without imaging, 183 had potential abdominal trauma. FAST was performed in 128 cases and recorded completely in 88. In 48% (42/88) the surgeon would have elected to cancel the CT based on the FAST and physical exam. One of the 42 cases had a positive FAST and required emergent laparotomy; the others were negative. The sensitivity of FAST for injuries requiring operation or blood transfusion was 87.5%. The sensitivity, specificity, PPV, and NPV in detecting pathologic free fluid were 50%, 85%, 53.8%, and 87.9%.

CONCLUSIONS:
True positive FAST exams are uncommon and would rarely direct management. While the negative FAST would have potentially reduced CT use due to practitioner reassurance, this reassurance may be unwarranted given the test's sensitivity.

The FAST Exam in Children-Trauma Pro

FAST is a helpful adjunct to the initial evaluation of adult trauma patients. Unfortunately, due to small numbers the usefulness is not as clear in children. In part, this is due to the fact that many children (particularly small children < 10 years old) have a small amount of fluid in the abdomen at baseline. This makes interpreting a FAST exam after trauma more difficult.

Despite this, use of FAST in children is widespread. A survey of 124 US trauma hospitals in 2007 showed an interesting pattern of ultrasound usage. In adult-only institutions 96% use
FAST, and at hospitals that see both adults and kids, 85% use it. Most of these centers that use FAST have no lower age limit, and the physician most commonly performing the exam was a surgeon. However, only 15% of children's hospitals do FAST exams, and they were usually done by nonsurgeons! The reasons for this are not clear. It appears that the pediatric surgeons have not embraced this technology as much as their adult counterparts.

What about that confusing bit of fluid found in kids? Several groups have looked at this (retrospectively). Fluid in the pelvis alone appears to be okay, but fluid anywhere else is a good predictor of solid organ injury. Fluid seen outside the pelvis had a 90% sensitivity and 97% specificity for injury, and positive and negative predictive values were 87% and 97% respectively.

**Bottom line:** FAST exam is useful in pediatric victims of blunt abdominal trauma. Fluid in the pelvis alone is normal in most children, but fluid seen anywhere else indicates a high probability of solid organ injury.

**References:**


Tranexamic acid administration to pediatric trauma patients in a combat setting: the pediatric trauma and tranexamic acid study (PED-TRAX).

**BACKGROUND:**

Early administration of tranexamic acid (TXA) has been associated with a reduction in mortality and blood product requirements in severely injured adults. It has also shown significantly reduced blood loss and transfusion requirements in major elective pediatric surgery, but no published data have examined the use of TXA in pediatric trauma.

**METHODS:**

This is a retrospective review of all pediatric trauma admissions to the North Atlantic Treaty Organization Role 3 hospital, Camp Bastion, Afghanistan, from 2008 to 2012. Univariate and logistic regression analyses of all patients and select subgroups were performed to identify factors associated with TXA use and mortality. Standard adult dosing of TXA was used in all patients.

**RESULTS:**

There were 766 injured patients 18 years or younger (mean [SD] age, 11 [5] years; 88% male; 73% penetrating injury; mean [SD], Injury Severity Score [ISS], 10 [9]; mean [SD] Glasgow Coma Scale [GCS] score, 12 [4]). Of these patients, 35% required transfusion in
the first 24 hours, 10% received massive transfusion, and 76% required surgery. Overall mortality was 9%. Of the 766 patients, 66 (9%) received TXA. The only independent predictors of TXA use were severe abdominal or extremity injury (Abbreviated Injury Scale [AIS] score ≥ 3) and a base deficit of greater than 5 (all p < 0.05). Patients who received TXA had greater injury severity, hypotension, acidosis, and coagulopathy versus the patients in the no-TXA group. After correction for demographics, injury type and severity, vitals, and laboratory parameters, TXA use was independently associated with decreased mortality among all patients (odds ratio, 0.3; p = 0.03) and showed similar trends for subgroups of severely injured (ISS > 15) and transfused patients. There was no significant difference in thromboembolic complications or other cardiovascular events. Propensity analysis confirmed the TXA-associated survival advantage and suggested significant improvements in discharge neurologic status as well as decreased ventilator dependence.

CONCLUSION:
TXA was used in approximately 10% of pediatric combat trauma patients, typically in the setting of severe abdominal or extremity trauma and metabolic acidosis. TXA administration was independently associated with decreased mortality. There were no adverse safety- or medication-related complications identified.