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Major trauma from suspected child abuse: a profile of the patient pathway

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WHAT IS ALREADY KNOWN ON THIS SUBJECT

Serious injury arising from child abuse affects mainly small infants.

Children severely injured from abuse have a higher mortality and a higher ISS, mainly from head injury.

Trauma networks are designed around the needs of adults and rely upon early identification of a severely injured patient for maximising survival.

WHAT THIS STUDY ADDS

Infants severely injured through child abuse present late to hospital and the majority arrive at non-major trauma centre designated hospitals via non-ambulance transport.

Gold standard emergency trauma care is less likely to be achieved in these children.

To achieve better patient outcomes, major trauma networks need to adapt their traditional response in order to identify and treat these infants.

Major trauma from suspected child abuse: a profile of the patient pathway

Abstract

BACKGROUND

Networked organised systems of care for major trauma patients now exist in many countries, designed around the needs of the majority patients (90% adults). Non-accidental injury is a significant cause of paediatric major trauma, and has a different injury and age profile from accidental injury[1]. This paper compares the pre-hospital and in-hospital phases of the patient pathway for children with suspected abuse, with those accidentally injured.

METHODS

The paediatric database of the national trauma registry of England and Wales, Trauma Audit and Research Network (TARN), was interrogated from April 2012 (the launch of the major trauma networks) to June 2015, comparing the patient pathway for cases of suspected abuse with accidentally injured children.

RESULTS

In the study population of 7825 children, 7344 were classified as accidental injury (AI), and 481 (6%) as suspected child abuse (SCA). SCA cases were younger (median 0.4 years vs 7 years for AI), had a higher Injury Severity Score (ISS median 16 vs 9 for AI), and nearly three times higher mortality (5.7% vs 2.2% for AI). Other differences included presentation to hospital evenly throughout the day and year, arrival by non-ambulance means to hospital (74%), and delayed presentation to hospital from the time of injury (median 8 hours vs 1.8 hours for AI). Despite more severe injuries these infants were less likely to receive key interventions in a timely manner. Only 20% arrived to a designated paediatric-capable Major Trauma Centre. Secondary transfer to specialist care, if needed, took a median of 21.6 hours from injury.

CONCLUSIONS

This data shows that children with major trauma that is inflicted rather than accidental follow a different pathway through the trauma system. The current model of major trauma care is not a good fit for the way in which child victims of suspected abuse present to healthcare. To achieve better care, awareness of this patient profile needs to increase, and trauma networks should adjust their conventional responses.

Introduction

Many developed countries have created organised networks of hospitals for major trauma care, through creating designated specialist centres in order to deliver better outcomes. This process happened in the UK in April 2012, with the formation of trauma networks and designated Major Trauma Centres (MTCs) similar to other countries. The Emergency Medical Services (EMS) decision about initial patient destination (MTC or nearest hospital) is based on distances and the patient's

condition. A pre-hospital triage tool is used to make this decision. The drivers to change in the delivery of trauma care were based mainly on evidence of improved outcome in adult patients.

Children account for around 10% of major trauma in developed world countries, and are known to present to the major trauma system in a different way from adults[2]. In recent years non-accidental injury (NAI) has been the fourth commonest mechanism of injury in children with major trauma[3]. Abused children form a distinct sub-set of paediatric trauma with different characteristics compared to children who are accidentally injured[1]. Differences in patient characteristics may affect the way in which health services need to respond. This is the first paper to compare key points in the patient pathway of children with accidental versus non-accidental injury.

Methods

The Trauma Audit and Research Network (TARN) database from April 2012-June 2015 was examined for patients under 16 years old. The patient demographics and key stages of the patient pathway were compared for cases of suspected child abuse (SCA) versus accidental injury (AI). Sub-group analysis for mortality rate was performed, where the outcome was known. The database records mortality at discharge from hospital, however in some instances where patients are transferred between hospitals TARN data may not be complete.

Patients are reported to the TARN database if they suffer injury and are either admitted to hospital for at least 3 days, admitted to a critical care area, are transferred for specialist care, or die in hospital. Patients who die before reaching hospital (no hospital resuscitation performed) are not included. Patients admitted to hospital directly and indirectly (via another hospital) in England and Wales are included. All 189 eligible hospitals contributed data during the time of the study.

TARN data coordinators (specifically trained clerical staff or nurses) in submitting hospitals enter "intent of injury" as a compulsory data field. SCA is a sub-category of intent that is used only when there is clear evidence in the hospital notes that the clinical staff were investigating child abuse with a high degree of suspicion. It is not possible for data coordinators to know whether if abuse was ultimately proven. Children with self-harm were excluded, as being neither accidentally injured or suspected child abuse. Also excluded were children categorised as "alleged assault" as previous scrutiny of these children[1] demonstrated that they were typically inter-personal injury of a non-abusive nature.

Cases of AI and SCA were compared for their age, injury severity, body area most severely injured, and crude mortality rate. Key stages in the patient pathway, from the time of injury to definitive specialist care, were compared. The pre-hospital phase analysis included mode of arrival to hospital, time of arrival (from time of injury), and Major Trauma Centre (MTC) designation of first and subsequent (secondary transfer) receiving hospitals (whether MTC or not). In the UK MTCs are sub-designated as adult-only, child-only or combined, however this is not the same worldwide, so in the analysis all MTCs were included as one group. Hospitals without specialist trauma services are designated a Trauma Unit (TU). The in-hospital phase of the patient pathway was analysed using the key stages defined in the 'dashboard' used for quality assurance within UK trauma networks. This quality dashboard includes time-based indicators for key stages of the patient pathway. These nationally set, time-based markers were therefore used to compare the two groups.

Data extraction and analysis was performed using SQL Server 2012, Excel (Microsoft, Redmond, CA), SPSS v22.0 (IBM Corp. Armonk, NY) and STATA (Statacorp, College Station, TX). Demographic and injury data were categorised and reported as number (percentage). Pearson's chi-squared test was used to test the distribution and significance of these variables. P values were derived from Pearson's chi-squared test. TARN has Health Research Authority (PIAGG Section 20) approval to conduct research on anonymised patient data.

Results

There were 8050 children recorded in the TARN dataset during the study period. There were no cases with missing data for "intent", as this is a compulsory data field. Figure 1 shows the case identification for this study, and the subset of cases used for the mortality calculation.

Figure 1: Case identification

Demographic comparisons between the 7344 cases of accidental injury (AI) and the 481 cases of suspected child abuse (SCA) are shown in table 1.

Table 1 Demographic comparison of AI and SCA cases (95% CIs)

		AI	SCA	Median of the difference*
	n	7344	481	
Age	median (IQR)	7 (3-12)	0.4 (0.2-0.9)	6.3 (6.0 to 6.6)
	Under 1	757 (10%)	363 (76%)	
	1 - 4	2191 (30%)	108 (23%)	
	5 - 10	2443 (33%)	1 (0.2%)	
	11 - 15	1953 (27%)	9 (2%)	
ISS	median (IQR)	9 (9-16)	16 (9-26)	-4 (-5 to -1)
	1 - 8	891 (12%)	72 (15%)	
	9 - 15	4288 (58%)	139 (29%)	
	>15	2165 (30%)	270 (56%)	
	GCS	15 (15-15)	15 (13-15)	0 (0 to 0)
AIS 3+	Head	1950 (27%)	269 (56%)	
	Limbs	3708 (51%)	127 (26%)	
	Thorax	593 (8%)	38 (8%)	
	Abdomen	536 (7%)	7 (2%)	

* based on Hodges-Lehmann test

There was a large difference in age range. Children with SCA were younger (median 0.4 years old, IQR 0.2-0.9) versus AI (median 7.2 years, IQR 2.6-12.3). The majority of children severely injured from suspected abuse were under the age of six months.

The Injury Severity Score for SCA was higher, median 16 versus a median of 9. The commonest body area severely injured (Abbreviated Injury Score 3+) was head injury in the SCA group (56% compared

with only 27% for AI group), whereas limb injury was the commonest body area in the AI group (51% compared with 26% in the SCA group).

When patients with ISS >15 was examined by year of age, the highest number of cases of severe trauma were in the under one-year olds (Figure 2), around half of which were SCA cases.

Figure 2. Patients ISS >15 by age

The higher overall ISS for cases of SCA was reflected in the crude mortality rate, which was 2.2% (95% CI 1.8-2.6) for the AI group and nearly treble that figure, 5.7% (95% CI 2.5-6.6) for the suspected abuse cases (Table 2).

Table 2 Patient outcome

		Category	
		AI	**SCA**
Outcome known		6923	440
Alive	n(%)	6773 (97.8%)	415 (94.3%)
	(95% CI)	(97 - 98)	(92 - 97)
Dead	n(%)	150 (2.2%)	25 (5.7%)
	(95% CI)	(1.8 - 2.5)	(3.5 - 7.8)

Table 3 compares the pre-hospital phase of the patient pathway for both patient groups, from time of injury to arrival at hospital, whether MTC or Trauma Unit (TU).

Table 3 Pre-hospital phase (95% CIs)

		AI			SCA			Median of the difference *
			95% CI			95% CI		
		n (%)	lower	upper	n (%)	lower	upper	
Arrival mode	Ambulance	3233 (44%)	43%	45%	123 (26%)	22%	30%	
	Car	129 (1.8%)	1.5%	2.1%	11 (2.3%)	1.0%	3.6%	
	Helicopter	556 (7.6%)	7%	8%	3 (0.6%)	0.0%	1.3%	
	Not recorded	3395 (46%)	45%	47%	344 (72%)	68%	76%	
	Other	31 (0.4%)	0.3%	0.5%	0			
Time to Arrival (median hours IQR)	All	1.8 (1.1-12.8)			8 (1.2-21.2)			-1.8 (-3.6 to -0.7)
	Direct to MTC	1.5 (1-9.3)			4.1 (0.8-18.6)			-0.5 (-1.3 to -0.2)
	To MTC via TU	13.8 (6.1-28)			21.6 (7.9-41)			-3.3 (-6.9 to -0.9)
Data missing (time to arrival)		181 (2.5%)	2.1%	2.8%	69 (14%)	11%	17%	
First hospital (n)	MTC	2965 (40%)	39%	42%	136 (28%)	24%	32%	
	Adult	*630 (8.6%)*	*8%*	*9%*	*38 (7.9%)*	*5.5%*	*10.3%*	
	Combined	*1409 (19%)*	*18%*	*20%*	*50 (10.4%)*	*7.7%*	*13.1*	

							%	
	Paediatric	*926 (13%)*	*12%*	*13%*	*48 (10%)*	*7.3%*	*12.7 %*	
Stayed at TU		*2798 (38%)*	*37%*	*39%*	*186 (39%)*	*34%*	*43%*	
Transfer from TU to MTC		*1581 (22%)*	*21%*	*22%*	*159 (33%)*	*29%*	*37%*	

* based on Hodges-Lehmann test

Fewer children with SCA arrived by organised Emergency Medical Services (EMS): ambulance 25.6% (95% CI 21.7-29.5%) vs 44% (95% CI 42.9-45.1%) or helicopter 0.6% (95% CI 0-1.3%) vs 7.6% (95% CI 7-8.2%). In many cases mode of arrival was not recorded (46.2% of AI cases and 71.5% of SCA cases). Due to the way in which the data entry is structured, if there is no pre-hospital data from EMS the mode of arrival is difficult to enter. So it is likely that all of the 'unrecorded' arrivals were outside the EMS system. From previous research within the TARN database we know that unrecorded cases represent arrival by car (meaning that the figure of 25.6% is probably an underestimate of non-use of the ambulance service).

Children with SCA took longer to reach a hospital from the time of injury (Table 3), with a median time of 8 hours (CI 1.2-21.2) compared with 1.5 hours (CI 1-9.3) in accidental injury. The need for secondary transfer to a MTC incurred similar delays in both groups, but combined parental and hospital delays mean that in the SCA group a MTC was not reached until a median of 21.6 hours (CI 7.9-41) after injury.

The majority of severely injured children initially arrived at a hospital without designated MTC status. Only 40% of children with AI arrived direct to a MTC, and even fewer with SCA (28%). Arrival to an MTC designated as 'adult-only' status (without specific paediatric trauma facilities) was seen in a significant number of patients (9% of AI and 8% of SCA cases). So only 32% of children with SCA arrived initially at an appropriate facility.

There was a difference in time of day of arrival to hospital (Figure 2). Arrival time in SCA was fairly evenly spread out between 08.00 hours to 20.00 hours, whereas children with AI mainly arrive from 15.00 – 20.00 hours (between end of school and bedtime).

Figure 3 Time of day of arrival

Differences were also seen for month of arrival. The UK (in the Northern Hemisphere) has more accidental injuries during the summer months (Figure 4), whereas SCA presents to hospital more evenly spread throughout the year.

Figure 4 Month of arrival

The in-hospital phase of the patient pathway (Table 4) shows differences in key treatment goals between the two groups. Children in the SCA group were less likely to be greeted by a consultant-led trauma team (34% v 61%), however this difference was not seen in the subgroup who were identified by the ambulance service as triage tool positive (77% v 87%).

Fewer SCA patients with a Glasgow Coma Score (GCS) of less than 9 received definitive airway management within 30 minutes of arrival (61% in SCA compared with 78% in AI), and fewer of those who required urgent head CT (GCS of less than 13 or other criteria based on national guidelines) were scanned within 60 minutes of arrival (28% in SCA compared with 84% in AI).

Table 4. In-hospital phase

	AI				SCA			
	Numerator n(%)	Denominator n	95% CI lower	upper	Numerator n(%)	Denominator n	95% CI lower	upper
n	**7344**				**481**			
Hospital deliver consultant led trauma teams ON ARRIVAL for patients with an Injury Severity Score greater than 15	1016 (60.8%)	1671	58.5%	63.1%	56 (34.4%)	163	27.1%	41.7%
Hospital deliver consultant led trauma teams ON ARRIVAL for triage positive patients	1061 (87.3%)	1215	85.4%	89.2%	17 (77.3%)	22	59.8%	94.8%
Proportion of patients with GCS <9 with definitive airway management within 30 minutes of arrival in ED	192 (78.4%)	245	73.2%	83.6%	17 (60.7%)	28	42.6%	78.8%
Proportion of patients with GCS < 13 that receive CT scan within 60 minutes of arrival	483 (72.1%)	670	68.7%	75.5%	18 (28.6%)	63	17.4%	39.8%
Proportion of patients meeting NICE head injury guidelines that receive CT scan within 60 minutes of arrival	327 (83.8%)	390	80.1%	87.5%	10 (27.8%)	36	13.2%	42.4%
Hospital administer Tranexamic Acid within 3 hours of incident to patients that receive blood products within 6 hours of incident	100 (88.5%)	113	82.6%	94.4%	0 (0%)	0	0.0%	0.0%
Hospital deliver definitive cover of open fractures within BOAST 4 guidelines	77 (33.6%)	229	27.5%	39.7%	0 (0%)	0	0.0%	0.0%

Patients transferred to MTC within 2 days of referral request	1519 (94.6%)	1606	93.5%	95.7%	158 (96.3%)	164	93.4%	99.2%
Patientswith ISS > 15 transferred to Paed MTC	661 (89.2%)	741	87.0%	91.4%	132 (91.7%)	144	87.2%	96.2%
Proportion of patients with an ISS of more than 8 that have a rehabilitation prescription completed	4708 (66.0%)	7130	64.9%	67.1%	322 (67.8%)	475	63.6%	72.0%

There were no differences seen in longer-term processes such onward transfer to an MTC within two days of request, transfer to a paediatric MTC for sicker patients, or completion of the rehabilitation prescription. In the SCA group there were no cases of open fracture and none received tranexamic acid.

Discussion

This paper is the first to consider how children with major trauma resulting from suspected child abuse (SCA) flow through the trauma care system, and has found previously unreported differences in the demographics and patient pathway. Networked systems of care for major trauma are based on early identification of severe injury, with transport direct to a specialist centre, and are designed predominantly around the needs of the majority of patients (adults). This improves outcomes for adults[4,5] and probably also for children[6]. However this paper shows that the current trauma system design is not optimal for injuries from SCA.

Our analysis of the TARN national dataset shows that children with SCA have very different characteristics from those with accidental injury (AI). In keeping with previous literature[1,6–12] this study confirmed that these infants form a distinct sub-set of major trauma cases. They are much younger (less than 6 months old), have a higher ISS (particularly severe head injury) and higher mortality. The injuries do not occur with the typical daily and seasonal pattern of accidental injury (occurring most frequently outside school hours and in the summer).

In the pre-hospital phase of care, despite sustaining more severe injuries children with SCA took a long time to arrive in hospital from the injury event (median 8 hours). Transport to hospital may be deliberately delayed by the abusers, and may require another person (eg. family member) to insist the child is brought to medical attention. Once a decision to seek medical help is made, the majority of cases will present to hospital by car, unannounced. Emergency Medical Services (EMS) were only called in 26% of cases, compared with 46% of AI. Very unwell infants are often brought to hospital without EMS involvement (infants are easy for parents to carry) so it may be that the age profile of these cases accounts for some of this difference in EMS use. However, EMS may be deliberately avoided, as EMS professionals will see the home circumstances and enquire into the mechanism of injury.

This combination of characteristics (age, injury pattern, time and mode of arrival) means that this sub-group of severely injured children present to the trauma networks in a different way from those accidentally injured.

Organised trauma care networks rely upon pre-hospital identification of major trauma, followed by triage direct to a Major Trauma Centre (MTC) rather than the nearest (non-specialist) hospital, and pre-alert of the MTC to assemble a receiving team of senior clinicians ready to deliver rapid clinical care and perform time-critical procedures. The high car conveyance rate in children (compared with adults) is a worldwide issue for paediatric trauma care. In the Australian New South Wales trauma registry[7] of 1138 children, only 30% of major trauma cases (all causes) arrived directly to a MTC. We have shown that the size of the problem is magnified in SCA. Delay in obtaining specialist care due to a combination of deliberate delay, non-EMS involvement, and subsequent arrival to "the wrong

place" is unavoidable. 68% presented to "the wrong place" (local hospital) and 74% arrived unannounced, by car.

This poses a significant organisational problem in delivering high quality trauma care. If secondary transfer to "the right place" is needed, the median time from time of injury to MTC arrival was very long (21.6 hours), compared with 13.8 hours in AI.

It seems that the pivotal point in treatment comes in identifying the infant as "a major trauma case". Examining the in-hospital phase of care, it seems that if an ambulance was called, and the child with SCA was identified as "a major trauma patient" by the pre-hospital triage tool, this group of patients received almost as good a standard of care (consultant-led trauma team in 77% of SCA and 87% of AI). Similar care was seen in the longer-term parameters such as onward inter-hospital transfer, and completion of the rehabilitation prescription.

However without this initial identification of the patient as a major trauma case, patients with SCA were only half as likely as one with AI to be received by a consultant-led team (34% versus 61% in patients ISS >15). Identification of an infant with a potentially high ISS is difficult, as ISS is calculated retrospectively, and injury may be occult at the time of first contact with EMS or hospital. The higher ISS in SCA cases was usually due to head injury. It is notoriously difficult to detect the subtleties of a decreased GCS in babies, so this triage trigger may be missing.

Without this pivotal identification of the abused infant as "a major trauma patient" it is likely that a "domino" effect then contributes to the failure to deliver key treatments in a timely manner. The trauma system will not have been activated and the hospital will be unprepared. A senior-led trauma team will not be already assembled to receive the patient (34% in SCA compared to 61% in AI). This leads to severely injured infants being initially assessed by junior staff, who may often be confused by a misleading history about the mechanism of injury (if injury is mentioned at all) and subtle clinical signs such as drowsiness. In the SCA group, definitive airway management was slower, as was time to CT scan.

If abuse is detected during this process, the additional work this brings may distract staff from staying focussed on time-critical trauma interventions. This work includes close supervision and questioning of the family, escalation to police and social services, contacting paediatricians, etc. Given all of these factors it is perhaps not surprising that there are long delays to key interventions.

The study limitations are those of any database analysis. While TARN data capture of major trauma cases from Emergency Departments is good, there is likely to be missing data since in clinical practice some cases of non-accidental injury present directly to paediatric wards with non-specific symptoms (drowsiness, vomiting etc). Some of these cases may not have been notified to the TARN database. Of those cases held within the TARN database, the number of SCA cases examined may be lower than those of actual abuse, due to the necessity to have a high degree of suspicion recorded in the medical records, for the data clerks to input SCA in the "injury intent" field. In the data showing ISS >15 in the under one population, AI is estimated as the mechanism of injury in 56% of cases. It is difficult in the UK for non-mobile infants to sustain major injury accidentally, so it may be that the number of SCA cases throughout the dataset may be an underestimate (because of the threshold for coding SCA as the injury intent). There is a large proportion of missing data for mode of arrival (46% of AI cases, 72% of SCA cases), which is most likely due to arrival by car (the pre-hospital section of

the data contains mode of arrival, but the section is not completed). Time to arrival on a Paediatric Intensive Care Unit was not specifically measured in this study, however is likely to be several hours in many cases, for those who required secondary transfer from a TU or an adult-only MTC.

CONCLUSION

Abusive injury forms a significant part of the paediatric trauma workload. As modern care of typical major trauma patients matures and improves, greater awareness of the "atypical major trauma case" is needed. There are interesting analogies with the elderly, who also present to major trauma networks in a way that means that they are not immediately identified as severely injured, and also experience delays in care (TARN Trauma in Older People report – in press).

Although older child victims of abuse attract greater media publicity (as there were potential missed opportunities for intervention by the authorities), seriously abused children are in fact much more likely to be under 6 months old. Child protection and trauma teaching must emphasise these characteristics of seriously injured abused infants.

This study shows that trauma care systems need to modify their conventional approach to activation, to enable early recognition of these infants and swift escalation up to "major trauma patient" status in order to minimise delays to delivery of definitive care. They will arrive unannounced with serious head injuries, several hours post-injury. This is particularly important for the non-MTC designated hospitals (who receive many of these patients). While the early parts of the patient pathway are unmodifiable, swifter activation of the trauma network will deliver better care and hopefully better patient outcomes to this vulnerable group.

Figure 1 Case identification

Figure 2 Patient ISS >15 by age

Figure 3 Time of day of arrival

Figure 4 Month of arrival

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