Epidemiology and aetiology of paediatric traumatic cardiac arrest in England and Wales.

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Contribution statement.

I can confirm that all authors made substantial contributions to (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted. JV takes responsibility for the manuscript as guarantor.

Epidemiology and aetiology of paediatric traumatic cardiac arrest in England and Wales.

Objective

To describe the epidemiology and aetiology of paediatric Traumatic Cardiac Arrest (TCA) in England and Wales.

Design

Population based analysis of the UK Trauma Audit Research Network (TARN) database.

Patients & Setting

All paediatric and adolescent patients with TCA recorded on the TARN database for a 10-year period (2006-2015).

Measures

Patient demographics, Injury Severity Score (ISS), location of TCA ('pre-hospital only', 'in-hospital only' or 'both'), interventions performed, and outcome.

Results

21,710 paediatric patients were included in the database; 129 (0.6%) sustained TCA meeting study inclusion criteria. The majority, 103 (79.8%), had a pre-hospital TCA. 62.8% were male, with a median age of 11.7 (3.4-16.6) years, and a median ISS of 34 (25-45). 110 (85.3%) had blunt injuries, with road-traffic collision the most common mechanism (n=73, 56.6%). 123 (95.3%) had severe haemorrhage and/or traumatic brain injury.

Overall 30-day survival was 5.4% ((95%CI 2.6-10.8), n=7). 'Pre-hospital only' TCA was associated with significantly higher survival (n=6) than those with TCA in both

'pre-hospital and in-hospital' (n=1) – 13.0% (95%CI 6.1-25.7) and 1.2% (95%CI 0.1-6.4) respectively, p<0.05. The greatest survival (n=6, 10.3% (95%CI 4.8-20.8) was observed in those transported to a paediatric MTC (defined as either a paediatric only MTC or combined adult-paediatric MTC).

Conclusions

Survival is possible from the resuscitation of children in TCA, with overall survival comparable to that reported in adults. The highest survival was observed in those with a pre-hospital only TCA, and those who were transported to a Major Trauma Centre. Early identification and aggressive management of paediatric TCA is advocated.

Epidemiology and aetiology of paediatric traumatic cardiac arrest in England and Wales.

Introduction

Trauma is the leading cause of death in those aged 1-18 years old.[1,2] Survival from cardiac arrest following trauma has been reported as being extremely poor, leading some to question whether attempting resuscitation in traumatic cardiac arrest (TCA) is futile, with concerns about the high rates of severe disability amongst survivors.[3,4] However, targeted resuscitation in select patient groups within the adult population has been associated with improved outcomes.[5]

In adults, the pathophysiology of TCA is fundamentally different to that of medical cardiac arrest, where there is frequently an underlying primary cardiac cause.[6] In children, medical cardiac arrest is most frequently the end result of respiratory or circulatory failure.[7] However, this difference in pathophysiology may be less marked in TCA; whilst physiological parameters and reserve may vary between age groups, the aetiology and sequence of events leading to final decompensation are likely to be similar. The principle aetiologies of TCA in adults are traumatic brain injury and haemorrhage; however, limited data exist for the paediatric population.[6]

In adults, survival from TCA has improved, and is now comparable to that of out-of-hospital medical cardiac arrest.[5] This increase in reported survival since 2005 is likely to be multifactorial, including the aggressive management of TCA, the introduction of treatment algorithms that emphasise the need for management of reversible causes of cardiac arrest (for example hypovolaemia), and a recognition that neurologically intact survival is possible.[6,8] It is logical that there has also been an increase in

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paediatric survival, but there are no published reports of the aetiology and epidemiology of paediatric TCA in the UK. Therefore, the aim of this study is to describe the aetiology and epidemiology of paediatric TCA in England and Wales over a ten-year period.

Materials and Methods

We used the Trauma Audit and Research Network (TARN) database to retrospectively analyse all paediatric and adolescent (age <18 years) trauma patients presenting to hospitals in England and Wales between 1 January 2006 and 31 December 2015. TARN was established over 25 years ago, and is the largest trauma registry in Europe, collecting data from all trauma receiving hospitals in England and Wales on patients with moderate to severe injuries. Study inclusion criteria were patients under 18 years with a recorded outcome who met the TARN inclusion criteria (an admission to hospital for three days or longer, intensive or high-dependency care, or transfer for further specialist care).[9]

The TARN database does not include patients who are pronounced life extinct pre-hospital (and are therefore not conveyed to hospital), and as such this group was not able to be reported in our study.

The European Resuscitation Council definition of TCA is a patient sustaining trauma with agonal or absent spontaneous respirations and in whom there is no central pulse.[10] TCA is not recorded as a discrete variable in the TARN database. Therefore, in this study TCA, in either the pre-hospital or in-hospital setting (or both), was defined as a Glasgow Coma Scale (GCS) score of 3 and a pulse or blood pressure of zero.[6] Only patients with a primary traumatic mechanism of injury (as a result of a transfer of energy) were included. Those with asphyxia/suffocation, drowning and high-voltage electrical injury as the cause of their arrest were excluded, as were those without a recorded GCS. Serious injuries were described using codes from the Abbreviated Injury Scale (AIS) score, with a score $\geq$ 3 used to denote serious injury.

For example serious traumatic brain injury (TBI) was defined as a head injury with an abbreviated injury scale score (AIS) ≥ 3 (for example: 1XXXXX.4 sub-dural haematoma <30mm), and serious haemorrhage (haemorrhage) was defined as any AIS ≥ 3 consistent with haemorrhage (for example: 5XXXXXX.5 splenic laceration).[6]

Survival from paediatric TCA is reported at 30 days (total, and by location of cardiac arrest – 'pre-hospital only', 'in-hospital only' or 'both'). Other outcomes reported include functional neurological outcome at discharge, an analysis of injury patterns and the association between TCA interventions performed and survival. Additionally, survival was compared for presentations within working hours (08:00-20:00) versus out-of-hours (20:00-08:00). Specific ethical approval was not required for this study; TARN has ethical approval (section 251) for research on anonymised data that is stored securely on the computer server at the University of Manchester.

The primary aim of this study was to report the 30-day survival following paediatric TCA in England and Wales. Secondary aims were to analyse injury patterns, report functional neurological outcome, and to describe associations between survival and interventions performed, in order to inform the future development of management protocols.

Statistical analyses were performed in Prism V.7.0 (GraphPad Software Inc, La Jolla, California, USA). Basic demographics and injury analysis data are reported as number (percentage) and median [inter-quartile range] as appropriate. Categorical data were analysed using a Chi square test, and continuous data were analysed with a

Mann Whitney U test. Odds ratios with 95% confidence intervals were calculated to

determine the independent association of survival with interventions performed, and

are reported as OR (95%CI). Significance was pre-defined as p<0.05.

Missing data

A comparison was made between patients with complete data and those removed due

to missing GCS to evaluate for a systematic difference with respect to age, Injury

Severity Score (ISS) and outcome.

Results

Over the 10-year study period, the TARN database included 279,581 patients with a known outcome. 21,710 patients (7.8%) were aged under 18 years; 275 (1.3%) met our definition of TCA. 51 (18.5%) patients were excluded as their GCS was not recorded, resulting in 224 (1.0%) TCA patients with complete data. A further 95 (34.5%) were excluded based on AIS code (e.g. non-energy transfer mechanisms such as asphyxiation and drowning). Therefore 129 (57.6%) patients were included in the data analysis, **Figure 1**. A comparison of patients with missing versus complete data is provided as **supplementary table 1.**

Figure 1: CONSORT diagram

Epidemiology of Paediatric TCA

Eighty-one (62.8%) paediatric TCA patients were male, with a median age of 11.7 [3.4-16.6] years and a median ISS of 34 [25-45] (see **Table 1**). Forty-six (35.7%) had a 'pre-hospital only' TCA, 57 (44.2%) were recorded as having both 'pre-hospital TCA and in-hospital TCA', with 26 (20.2%) having 'in-hospital only' TCA.

Primary Aim

Seven patients (5.4%, (95% CI 2.7-10.8)) survived to 30 days, with six (4.7%, (95%CI 2.1-9.8)) discharged alive. There were no survivors from 'in-hospital only' TCA. Those with a 'pre-hospital only TCA' (n=6) were significantly (p=0.04) more likely to survive than those with 'pre-hospital and in-hospital TCA' (n=1); 13.0% (95%CI 6.1-25.7) versus 1.2% (95%CI 0.1-6.4).

Injury Pattern

110 (85.3%) TCA patients had a blunt mechanism of injury, and the remaining 19 suffered a penetrating mechanism. There was no statistically significant difference in survival between blunt and penetrating injury (OR 1.04 (95%CI 0.2-12.5), p=1.0). Road traffic collisions were the most prevalent mechanism of injury (n=73, 56.6%), followed by stabbing and shootings (n=18, 14.0%) and falls over two metres (n=16, 12.4%), **Table 1**.

32 (24.8%) patients had TCA associated with haemorrhage in isolation, 20 (15.5%) TBI in isolation with 71 (55.0%) having TCA associated with both TBI and haemorrhage. Survival was lowest in those with TBI and haemorrhage (n=1, 1.4%) compared to isolated TBI (n=2, 10.0%, (95%CI 1.8-30.1)) or haemorrhage (n=3, 9.4%, (95%CI 3.2-24.2)). Severe injuries to the thorax (AIS $\geq$ 3) formed the majority of those patients with a haemorrhagic cause (n=23, 71.9%, 95%CI 54.6-84.4), and severe (AIS $\geq$ 3) injuries to the Face, Neck, Spine and Back (n=3, 50%) in those without TBI/ haemorrhage, **Table 2**.

Receiving hospital & time of day

Seventy-three (56.6%) patients were initially transported to a Major Trauma Centre (MTC), the UK equivalent of Level 1 Trauma Centre. The greatest survival (n=6, 10.3% (95%CI 4.8-20.8) was observed in those transported to a paediatric MTC (defined as either a paediatric only MTC or combined adult-paediatric MTC). 83 (64.3%) patients presented to the ED between 08:00-20:00, with 13 (10%) presenting after midnight. No statistical difference in survival was observed between

presentations occurring within working hours versus out-of-hours, 6.0% (95%CI 2.6-13.3) vs 4.4% (95%CI 0.8-14.8) respectively, p=1.0.

Interventions

Blood products (during the pre-hospital and in-hospital phases) were administered to over half of the TCA group (n=66, 51.2%), but this did not have a significant association with survival (OR 1.29(0.3-5.3, p=1.0)), **Table 3**. Those who survived received a greater number of blood products (7 units [2.3-19.3] vs. 3 units [1-5.3]), but this did not reach significance, p=0.38 (and may be due to the fact that patients who survived had greater opportunity to receive blood products). 78 (60.5%) of the cohort received closed chest compressions, and 113 (87.6%) underwent endotracheal intubation, **Table 3**. The presence of a pre-hospital doctor (n=43, 41.7%) was not significantly associated with an improvement in survival (OR 0.51(0.1-2.0, p=0.5)). Eighteen TCA patients (14.0%) underwent resuscitative thoracotomy (RT) – the majority (n=12, 85.7%) had sustained severe (AIS ≥3) penetrating thoracic injury, and there were no survivors. Therefore, initial transport to an MTC, compared to a Trauma Unit (non Level 1 Trauma Centre), was the only examined intervention that was associated with improved survival in paediatric TCA (p=0.02), **Table 4.**

Functional Outcome

Six (85.7%) of the seven TCA patients who survived to 30 days had a Glasgow Outcome Score recorded at discharge. Of these, one (16.7%) died after 30 days in hospital, one was discharged with severe disability, two with moderate (33.4%) and two (33.4%) good functional outcome (see **Table 5).**

Missing Data

When cases with missing GCS (n=51) were compared to the complete study

population (n=129), a statistically significant difference was observed in both median

ISS (p=0.006) and outcome (p<0.001). Cases with missing GCS had a lower median

ISS (26 vs 34) correlating with a higher survival (15 vs 7). Whilst cases with missing

GCS were older (14.8 vs 11.7), this did not demonstrate significance (p=0.07). The

leading mechanism of injury in both cohorts was road traffic collisions (missing

43.1% vs. complete 56.6%), followed by stabbings and shootings (missing 21.6% vs

complete 14.0%).

Discussion

This study has shown that from the TARN database, the survival of paediatric patients who go into TCA in the pre-hospital setting and are transported to hospitals in England and Wales or who arrest in-hospital is 5.4% (95%CI 2.2-10.9). This challenges the historically held belief that there are no survivors from TCA; of patients sustaining a TCA and achieving a return of spontaneous circulation (ROSC) in the pre-hospital setting, survival was 13.0%. We have also demonstrated that the highest survival is observed in those who are transported to paediatric MTCs.

A wide range of survival following paediatric TCA is reported in the literature, from 1.9% to 25.2%; with a number of studies suggesting that resuscitation is futile and should not be attempted.[7,10-12] This difference in survival is likely to be multi-factorial, with varying sample sizes, different definitions of TCA, presence of different inclusion/exclusion criteria and the maturity of the providing trauma service all likely to be contributing factors. The relatively low rate of survival seen in our study may be attributable to our exclusion criteria, and the removal of cases associated with drowning, asphyxiation, hanging and electrocution, all of which have been associated with higher rates of survival.[13,14] A previous UK study demonstrated a survival rate of 8.8% (n=7), but three cases were as a result of a primary hypoxic insult (hanging or drowning).[13] Excluding these cases would reduce overall survival to 5.0%, which is comparable to that observed in our study.[13]

Similar to findings in other reports, 18 patients in our study underwent RT, with no recorded survivors.[13] Despite low survival rates, the American College of Surgeons advocate that for adults, thoracotomy continues to be undertaken in patients with

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exsanguinating abdominal injuries and non-cardiac penetrating injuries.[4] There is no specific guidance available for the paediatric population. However, it is likely that older teenagers, aged 16 or over (who represented 72.2% of those undergoing RT in our study) can be managed according to adult TCA algorithms. In our study 50.0% of these procedures were performed in the pre-hospital environment with 13 (72.2%) following penetrating trauma, revealing severe thoracic and abdominal injuries in 17 patients (94.4%). Whilst we acknowledge the survival rate is poor, it should be recognised that for the management of haemorrhagic TCA, pre-hospital interventions other than RT, for example Resuscitative Emergency Balloon Occlusion of the Aorta (REBOA) or Selective Aortic Arch Perfusion (SAAP) are still experimental and are unlikely to be widely available in the near future.[15,16]

Successful management of adult TCA is frequently attributed to the rapid and aggressive correction of potentially reversible causes with life-saving interventions.[8] These interventions include but are not limited to endotracheal intubation (for oxygenation), bilateral thoracocentesis or thoracostomy (for evolving pneumothorax), high-volume intravascular filling (for hypovolaemia), and within certain patient groups RT.[17,18]

The variability in recorded interventions observed in this study raises the question as to whether all patients in TCA should be treated in the same way. In order to facilitate the expedient (and necessary) management of TCA the diagnosis is based on a simple clinical diagnosis (agonal or absent respirations and the lack of a central pulse), and a universal management algorithm.[10] However, the aetiology of TCA is often multi-factorial and not immediately apparent (with the exception of penetrating

thoracic injury). The same dilemma does not occur in medical cardiac arrest where cardiopulmonary resuscitation (ventilation and closed chest compressions) are a well proven intervention that can be immediately used as a 'holding measure' while the aetiology of the arrest is confirmed.[4] The use of chest compressions in TCA has recently been de-emphasised in favour of addressing potentially reversible causes.[8,10] This argument is most valid in hypovolaemic TCA (where in a low-output state aggressive intravenous filling is a priority)[6], but is potentially detrimental to other aetiologies (for example 'isolated TBI' or impact brain apnoea).[19] This attitude may explain the relatively low proportion of patients (60.5%) in our study reported as receiving chest compressions, but from the data available it is not possible to further explain this, and it may also be due to a lack of accurate recording.

Within the adult population it has been speculated that the provision of an experienced pre-hospital physician as part of a well-governed pre-hospital trauma service improves survival.[5,6] Contrary to this within the paediatric population, lower mortality has been reported in TCA attended by non-physician Emergency Medical Services (EMS) in the USA compared to European studies with predominately physician-led EMS.[11] Our study reported no difference in survival with the presence of a pre-hospital physician.

Paediatric TCA is a high acuity, low frequency event as demonstrated by data recorded on the TARN database. Despite our study covering a 10 year period, only 180 cases were recorded in England and Wales (with complete data available for 129 (71.7%) cases). Of these cases, six (4.7%) survived to hospital discharge, with four (3.1%) having at best moderate disability recorded on discharge using the GOS.

Whilst this is a low number, it demonstrates that survival with a good outcome is possible from TCA. Therefore, as with adult TCA, a standardised, aggressive approach to the management of these patients is advocated.

Limitations

We acknowledge that there are a number of limitations to our study. Firstly, as TCA is not a recorded variable on the TARN database, surrogates were required to identify our study population. Identification of individuals in TCA is reliant on the treating hospitals submitting data to TARN. There is a disparity in data submission between MTCs and TUs, and therefore we cannot guarantee capture of the entire paediatric TCA population. Additionally, the TARN database does not include patients who are declared dead at scene and not conveyed to hospital.

A number of patients (n=51, 18.5%) were excluded from our analysis due to incomplete recording of GCS. To explore any effects of this missing data, an analysis was conducted which demonstrated that those with missing data were less likely to be severely injured (lower median ISS) and with a greater frequency of survivors.

Whilst the results from this study demonstrate higher survival in paediatric TCA treated at MTCs compared to TUs, this has the limitation of being an unadjusted analysis. Additionally, with existing trauma triage criteria in England and Wales, it is very likely that EMS crews conveying patients in TCA from the pre-hospital setting will go to the nearest TU if it is a long distance to the MTC. This is likely to influence the reported survival but due to the nature of the TARN database we are unable to determine the geographic location of the TCA and whether a TU was indeed bypassed for a MTC.

With low study numbers, we must be cautious when interpreting the results especially with regards to statistical significance. This is particularly relevant when discussing

the benefits of providing life-saving interventions, and when no cases were reported

in contingency analyses, we were unable to provide odds ratios (RT, endotracheal

intubation and treatment at an MTC). Whilst we have attempted to report the

functional neurological outcome at discharge, this is limited by the Glasgow Outcome

Scale (GOS) being the only measure recorded on TARN during this study period. We

acknowledge that there are two key limitations with using the GOS in this population.

Firstly, the validity of the GOS has not been determined in the paediatric population[20]

and secondly, varying degrees of impairment are possible, even in those recorded as

having a 'good outcome'. Morbidity and mortality beyond 30 days is not recorded in

the TARN database, and we were therefore not able to report longer term outcomes.

Conclusion

Using a large civilian registry population, we have demonstrated that survival of paediatric TCA, in patients arresting in the pre-hospital setting and who are transported to hospital or those who arrest in hospital is 5.4%. Survivors are possible from the resuscitation of paediatric TCA. A significant proportion of paediatric TCA is managed in Trauma Units – we therefore recommend the development of a standardised, best practice approach guideline.

Conflicts of interest

None declared by any author.

Acknowledgements

What is already known on this topic.

- Paediatric TCA is a low frequency, high acuity event associated with high morbidity.

- In the adult population, targeted and aggressive resuscitation from TCA has led to improvements in survival, comparable to all Out-of-Hospital Cardiac Arrests.

What this study adds.

- Survivors are possible from the resuscitation of paediatric TCA.

- A significant amount of paediatric TCA is managed in Trauma Units and not Major Trauma Centres.

- Of those paediatric TCA patients that achieved ROSC in the pre-hospital setting and were transported to hospital, 13.0% survived.

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	All Cases	Pre-hospital only TCA	Pre-hospital and In-hospital TCA	In-hospital only TCA
Demographics				
N (%)	129	46 (35.7%)	57 (44.2%)	26 (20.2%)
Male	81 (62.8%)	26 (56.5%)	41 (71.9%)	14 (53.8%)
Median age [IQR]/years	11.7 (3.4-16.6)	12.1 (3.5-16.8)	12.3 (4-16.6)	6.8 (3.0-15.8)
Injury severity score				
ISS (median [IQR])	34 (25-45)	34 (26.8-50.0)	34 (25.0-46.5)	28 (24.0-42.0)
1-8/N (%)	0	0	0	0
9-15/N (%)	2	0	2 (3.5%)	0
16-75/N (%)	127	46 (100%)	55 (96.5%)	26 (100%)
30 day survival				
Overall/N (%)	7 (5.4%)	6 (13.0%)	1 (1.8%)	0
Blunt/N (%)	6 (5.5%)	5 (12.5%)	1 (2.2%)	0
Penetrating/N (%)	1 (5.3%)	1 (16.7%)	0	0
Mode of injury				
Blunt/N (%)	110 (85.3%)	40 (87.0%)	46 (80.7%)	24 (92.3%)
Penetrating/N (%)	19 (14.7%)	6 (13.0%)	11 (19.3%)	2 (7.7%)
Mechanism of injury				
RTC/N (%)	73 (56.6%)	26 (56.5%)	29 (50.9%)	18 (69.2%)
Fall >2m/N (%)	16 (12.4%)	7 (15.2%)	9 (15.8%)	0
Fall <2m/N (%)	2 (1.6%)	1 (2.2%)	0	1 (3.8%)
Stab/shot/N (%)	18 (14.0%)	5 (10.9%)	11 (19.3%)	2 (7.7%)
Blow/N (%)	7 (5.4%)	1 (2.2%)	4 (7.0%)	2 (7.7%)
Other/N (%)	13 (10.1%)	6 (13.0%)	4 (7.0%)	3 (11.5%)
Injury Intent				
Non intentional	85 (65.9%)	31 (67.4%)	35 (61.4%)	19 (73.1%)
Alleged Assault	16 (12.4%)	4 (8.7%)	10 (17.5%)	2 (7.7%)
Suspected Child Abuse	10 (7.8%)	2 (4.3%)	5 (8.8%)	3 (11.5%)
Suspected Self Harm	7 (5.4%)	2 (4.3%)	3 (5.3%)	2 (7.7%)
Sport	1 (0.8%)	1 (2.2%)	0	0
Suspected High Risk Behaviour	3 (2.3%)	2 (4.3%)	1 (1.8%)	0
Intent Inconclusive	7 (5.4%)	4 (8.7%)	3 (5.3%)	0
Receiving Hospital				
Non-MTC	56 (43.4%)	15 (32.6%)	28 (49.1%)	13 (50.0%)
Paediatric MTC	8 (6.2%)	3 (6.5%)	4 (7.0%)	1 (3.8%)
Combined Paed/Adult MTC	50 (38.8%)	21 (45.7%)	19 (33.3%)	10 (38.5%)
Adult MTC	15 (11.6%)	7 (15.2%)	6 (10.5%)	2 (7.7%)
Arrival Time				
00:00-07:59	13 (10.1%)	5 (10.9%)	4 (7.0%)	4 (15.4%)
08:00-15:59	42 (32.6%)	13 (28.3%)	20 (35.1%)	9 (34.6%)
16:00-19:59	41 (31.8%)	15 (32.6%)	17 (29.8%)	9 (34.6%)
20:00-23:59	32 (24.8%)	13 (28.3%)	16 (28.1%)	3 (11.5%)
AIS ≥3				
Head	91 (70.5%)	35 (76.1%)	37 (64.9%)	19 (73.1%)
Thorax	86 (66.7%)	30 (65.2%)	41 (71.9%)	15 (57.7%)
Abdomen	25 (19.4%)	7 (15.2%)	11 (19.3%)	7 (26.9%)
Limb	37 (28.7%)	11 (23.9%)	19 (33.3%)	7 (26.9%)
FNSB	48 (37.2%)	8 (17.4%)	7 (12.3%)	2 (7.7%)

Table 1: Demographics.

ISS – Injury Severity Score, RTC – Road Traffic Collision, MTC – Major Trauma Centre, AIS – Abbreviated Injury Scale, FNSB – Face, Neck, Spine, Back

	TBI Only	**Haemorrhage only**	**TBI & Haemorrhage**	**No haemorrhage or TBI**
N/(%)	20 (15.5%)	32 (24.8%)	71 (55.0%)	6 (4.7%)
Male/(%)	9 (45.0%)	28 (87.5%)	43 (60.6%)	1 (16.7%)
Median Age [IQR]/years	9.0 [3.2-15.7]	16.3 [8.1-17.5]	8.4 [2.8-15.0]	16.1 [3.0-17.0]
ISS, Median [IQR]	31.0 [19.5-40.3]	26.0 [25.0-40.3]	38.0 [29.0-50.0]	22.5 [16.0-75.0]
Blunt	20 (100%)	15 (46.9%)	70 (98.6%)	5 (83.3%)
Penetrating	0	17 (53.1%)	1 (1.4%)	1 (16.7%)
RTC	11 (55.0%)	10 (31.3%)	50 (70.4%)	2 (33.3%)
Fall >2m	1 (5.0%)	2 (6.3%)	12 (16.9%)	1 (16.7%)
Fall <2m	1 (5.0%)	1 (3.1%)	0	0
Stabbing/Shooting	0	17 (53.2%)	0	1 (16.7%)
Blow	2 (10.0%)	1 (3.1%)	4 (5.6%)	0
Other	5 (25.0%)	1 (3.1%)	5 (7.0%)	2 (33.3%)
30 day survival (overall)	2 (10.0%)	3 (9.4%)	1 (1.4%)	1 (16.7%)
Trauma Unit receiving	9 (45.0%)	7 (21.9%)	37 (52.1%)	3 (50.0%)

Table 2: Causes of traumatic cardiac arrest.

TBI – Traumatic brain injury, ISS – Injury Severity Score, RTC – Road Traffic Collision,

	ISS	N (%) received	N (%) survived	OR (95% CI) survival vs. no intervention	P Value
Blood product administration	34 (25-45)	66 (51.2%)	4 (6.1%)	1.29 (0.334-5.281)	P=1.0*
Chest compressions	34 (25-45)	78 (60.5%)	3 (3.9%)	0.47 (0.115-1.825)	p=0.43
Defibrillation	25 (17-38)	11 (8.5%)	1 (9.1%)	1.87 (0.149-14.61)	p=0.47
Endotracheal intubation	34 (25-45)	113 (87.6%)	7 (6.2%)	n/a[1]	p=0.60
Major Trauma Centre[2]	29 (25-45)	73 (56.6%)	7 (9.6%)	n/a[1]	p=0.02
Pre-hospital doctor	30 (25-45)	43 (41.7%)	4 (9.3%)	0.51 (0.125-2.011)	p=0.45
Resuscitative Thoracotomy	26 (25-30.5)	18 (14.0%)	0	n/a[1]	p=0.59
Thoracocentesis	42 (26.4-49)	33 (25.6%)	1 (3.0%)	0.47 (0.040-3.103)	p=0.68

Table 3: Interventions performed.

[1] Odds ratios not calculable due to zero values in contingency analyses.
[2] All MTCs – adult, paediatric and combined.

Demographics	
N (%)	7 (5.4%)
Median Age [IQR]/years	4.7 (0.5-15.5)
Male n (%)	3 (42.9%)
ISS (median [IQR])	34.0 (16.0-34.0)
Mode of injury, n (%)	
Blunt,	6 (85.7%)
Penetrating	1 (14.3%)
Mechanism of injury	
RTC	2 (28.6%)
Shooting/Stabbing	1 (14.3%)
Blow	1 (14.3%)
Other	3 (42.9%)
Cause	
TBI only	2 (28.6%)
Haemorrhage only	3 (42.9%)
TBI & Haemorrhage	1 (14.3%)
Neither	1 (14.3%)
TCA Location	
PH TCA	6 (85.7%)
ED TCA	1 (14.3%)
Time of Day, n (%)	
00:00-07:59	1 (14.3%)
08:00-15:59	1 (14.3%)
16:00-19:59	4 (57.1%)
20:00-23:59	1 (14.3%)
Receiving Hospital, n (%)	
Adult MTC	1 (14.3%)
Paediatric MTC	6 (85.7%)
Interventions, n (%)	
Intubation,	7 (100%)
Thoracocentesis	1 (14.3%)
Thoracotomy	0 (0%)
Blood[1]	4 (57.1%)
Defibrillation	1 (14.3%)
Tranexamic Acid	3 (42.9%)
Prehospital Doctor	4 (57.1%)
Glasgow Outcome Scale	
Death	1 (14.3%)
Severe Disability	1 (14.3%)
Moderate Disability	2 (28.6%)
Good Outcome	2 (28.6%)
Not recorded	1 (14.3%)

Table 4: Survivors.

ISS – injury severity score, RTC – Road traffic collision, TBI – Traumatic brain injury, PH – Prehospital, ED – Emergency Department, TCA – Traumatic Cardiac Arrest, MTC – major trauma centre.

Glasgow Outcome Scale	TBI & Haemorrhage	TBI alone	Haemorrhage alone	Neither TBI or Haemorrhage	Total
Death	0	0	1	0	1 (16.7%)
Severe disability	0	0	1	0	1 (16.7%)
Moderate disability/good recovery	1	1	1	1	4 (66.7%)
N with available data (% total survivors at 30-days)	*1*	*1*	*3*	*1*	*6 (85.7%)*

Table 5: Glasgow Outcome Scale at hospital discharge.

	Age (Median, IQR)	ISS (Median, IQR)	Outcome (Alive)
Complete dataset (n=129)	11.7 (3.4-16.6)	34 (25-45)	7 (5.4%)
Missing GCS (n=51)	14.8 (5.6-17.1)	26 (16-42)	15 (29.4%)

Supplementary Table 1: Comparison between missing and complete datasets.