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Clinical paper

Epidemiology and aetiology of traumatic cardiac arrest in England and Wales — A retrospective database analysis☆

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ABSTRACT

Background: Historically, reported survival from traumatic cardiac arrest (TCA) was extremely low. More recent publications have recorded survival to discharge of up to 8%. This improvement is likely to be multi-factorial; however, there are currently no published data describing the epidemiology or aetiology of TCA in England and Wales to guide future practice improvement.
Methods: Population-based analysis of 2009–2015 Trauma Audit and Research Network (TARN) data. The primary aim was to describe the 30-day survival following TCA. Patients of all ages with traumatic cardiac arrest pre-hospital or in the emergency department (ED) were included. Data are described as number (%), and median [interquartile range]. Two-group analysis with Chi-squared test was performed.
Results: During the study period 227,944 patients were included in the TARN database. Seven hundred and five (0.3%) suffered TCA: 74.3% were male, aged 44.3 [25.2–83.2] years, ISS 29 [21–75], and 601 (85.2%) had blunt injuries. 612 (86.8%) had a severe traumatic brain injury and or severe haemorrhage.

Overall 30-day survival was 7.5% (95%CI 5.6–9.5) — 'pre-hospital only' TCA 11.5%, 'ED only' TCA 3.9%, $p < 0.02$. No patients who were in TCA both pre-hospital and in the ED survived.
Conclusion: This study has shown that short-term survival from TCA in this large civilian registry is 7.5%. Early and aggressive management of patients with TCA, using protocols that target the reversible causes of TCA, should be initiated. Further work to establish novel ways to manage patients with reversible causes of TCA is indicated. Resuscitation in this patient group is not futile.

Introduction

Traumatic cardiac arrest (TCA) is fundamentally different to medical cardiac arrest with different causes and underlying pathophysiology. In medical cardiac arrest the majority of adult patients have a primary cardiac cause,[1] whereas in TCA the leading causes are traumatic brain injury (TBI) and haemorrhage.[2] Until recently protocols for the management of cardiac arrest have not differentiated between medical and traumatic aetiology. Historical observational studies of TCA outcome have reported extremely low survival: between 1.5% and 2.6%.[3,4] This has led some authors to suggest that resuscitation of patients in TCA is futile.[5]

More recent publications, using data from modern trauma systems, have reported TCA survival rates comparable to those for out-of-hospital medical cardiac arrest. Data from a UK pre-hospital trauma service, a Spanish pre-hospital trauma service, and the German trauma registry quote overall survival of between 6.6% and 9.7%.[6–8] Data from the United Kingdom military has reported an 8% overall survival in TCA,[9] and a 21.5% survival in those undergoing resuscitative thoracotomy.[10] Furthermore, within these studies there is some evidence that earlier intervention, the presence of pre-hospital physicians, and the use of resuscitative thoracotomy may improve outcomes from TCA.

Protocolisation of TCA management,[11] together with the formalisation of physician pre-hospital training in the UK,[12] the capability to transfuse blood products out of hospital,[13] and novel interventions (for example resuscitative endovascular bal-

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loon occlusion of the aorta)[14] provide a potential opportunity to make a significant impact on the survival rate of TCA. In order to support these changes in practice it is imperative to know the scale of the TCA problem, but this has not been formally reported in the UK trauma population. The aim of this study is to describe the aetiology and epidemiology of TCA in a large population of UK trauma patients.

Methods

We conducted a retrospective analysis of trauma patients presenting to hospitals in England and Wales between 1st January, 2009 and 30th September, 2015. Data were obtained from the Trauma Audit and Research Network (TARN) database.

TARN was established 25 years ago and now holds the largest trauma registry in Europe. It is the national clinical audit for trauma care, which collects data on patients with moderate to major injuries from all trauma receiving hospitals in England, Wales and the Republic of Ireland with participation from some hospitals across other parts of Europe. The information is submitted electronically by each hospital to TARN via a web-based data collection system and follows the patient pathway from pre-hospital to discharge including key observations and interventions. Outcome at 30 days is determined by reference to hospital records for inpatients and via linkage to office for National Statistics data for those who have been discharged. Since 2008 TARN has additionally collected data on functional neurological outcome at the time of hospital discharge using the five-point Glasgow Outcome Scale.[15]

Inclusion criteria for this study were patients of all ages, with a known 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). In 2009, at the start of this study, 69% of hospitals in England and Wales were submitting data to TARN. This increased substantially from 2012, with 100% participation by 2014.

The definition of TCA is a patient who has sustained trauma with agonal or absent spontaneous respiration and absence of a central pulse.[16] TCA is not reported as a separate variable in the TARN database, and it was therefore necessary to manually sift records to identify trauma patients with a Glasgow Coma Scale score (GCS) of 3 together with a pulse or blood pressure of zero. Patients without a recorded GCS were excluded, as were those with abbreviated injury scale (AIS) codes describing asphyxia/suffocation, drowning, and high-voltage electrical injury (as their management differs from that of primary TCA). The TARN database does not include patients who are 'pronounced life extinct' at the pre-hospital scene, and therefore not conveyed to hospital. In analysis of injury type severe traumatic brain injury (TBI) was defined as a head AIS $\geq$ 3 and severe haemorrhage as an AIS $\geq$ 3 injury consistent with haemorrhage.

The primary aim was to identify the survival from TCA at 30 days (total, and by location of TCA — 'pre-hospital only', 'ED only', or TCA in both locations). Patients with TCA occurring in hospital but after ED discharge were excluded. The secondary aims included an analysis of injury patterns, functional outcome at hospital discharge, and interventions performed. There are a number of potentially lifesaving interventions in the management of TCA. We analysed the TCA dataset to report the prevalence of these interventions with the assumption that they have an independent effect on survival.

Data analysis

Basic demographics, admission physiology and injury data have been reported as number (percentage), as mean (95% confidence interval), or as median [inter-quartile range] as appropriate. Continuous data have been analysed using the Mann–Whitney U test, and categorical data were analysed using the Chi square test. The independent association of survival at 30 days has been described as an odds ratio (95% confidence interval). All statistical analyses were performed with SPSS v22.0 (IBM Corp., Armonk, NY, USA).

Ethical approval

TARN has ethical approval (Section 251) for research on the anonymised data that are stored securely on the University of Manchester server.

Results

Between January 2009 and September 2015, 227,944 patients with a known outcome at 30 days were included in the TARN database. 1305 (0.6%) of patients met our definition of TCA, however 177 did not have a recorded GCS score, resulting in 1128 patients in TCA with complete data. 423 of these TCA patients met an AIS code exclusion criteria (asphyxiation/suffocation n = 279, drowning n = 125, burns n = 12, high-voltage electrical injury n = 7) — therefore 705 (0.3%) patients were included in the final data analysis.

Epidemiology of TCA

Five hundred and twenty-four (74.3%) of the TCA patients were male, with a median age of 44.3 [25.2–83.2] years old, and a median injury severity score (ISS) of 29 [21–75]. 416 (59.0%) of patients had a 'pre-hospital only' TCA, 160 (22.7%) were recorded as both 'pre-hospital and in ED TCA', and 129 (18.3%) had an 'ED only' TCA, Table 1.

Primary aim

Fifty-three patients (7.5% (95%CI 5.6–9.5)) survived to 30 days. None of the 160 patients with TCA recorded in both locations survived. Those with a 'pre-hospital only' TCA were significantly more likely than those with an 'ED only TCA' to survive — 11.5% (95%CI 8.5–14.7) versus 3.9% (95%CI 0.5–7.3), $p < 0.02$, Table 1.

Secondary aims

Injury pattern

601 (85.2%) of TCA patients had a blunt mode of injury, and 104 were penetrating. There was no statistically significant difference in survival odds after blunt or penetrating trauma. The highest survival group was 'pre-hospital only' TCA after blunt trauma (n = 46/367, 12.5%). Road traffic collision was the most prevalent mechanism of injury, followed by a fall over two metres, and then stabbings and shootings, Table 1.

Traumatic brain injury (TBI) and haemorrhage are consistently reported as the leading causes of traumatic death.[2] We therefore examined this dataset to report the prevalence of these injuries: 612 (86.8%) of TCA patients had a severe TBI (head AIS $\geq$ 3) and or an AIS $\geq$ 3 indicating a severe haemorrhagic injury. There was considerable overlap in these two conditions; 269 (38.2%) patients had both severe TBI and a severe haemorrhagic injury. Patients with both conditions in combination had a lower survival than those with only severe TBI or only severe haemorrhagic injury, (2.2% compared to 10.2% respectively, $p < 0.001$), Table 2.

In the 93 (13.2%) patients in TCA without an AIS $\geq$ 3 for head or haemorrhagic injury ('no TBI, no haemorrhage' group) the most prevalent body region injured was spine (n = 39, 41.9%), followed by thorax (n = 38, 40.9%). Sixty-nine (74.2%) of these patients had a pre-hospital only TCA, and overall survival at 30 days was higher than other groups (12.9%), Table 2.