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Emergency medical dispatch recognition, clinical intervention and outcome of patients in cardiac arrest from major trauma – an observational study

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Abstract

Objectives

The aim of this study is to describe the demographics of reported traumatic cardiac arrest (TCA) victims, pre-hospital resuscitation and survival to hospital rate.

Setting

Helicopter Emergency Medical Service in southeast England, covering a resident population of 4.5 million and a transient population of up to 8 million people.

Participants

Patients reported on the initial 999 call to be in suspected traumatic cardiac arrest between 01/07/2016 – 31/12/2016 within the trust's geographical region were identified. The inclusion criteria were all cases of reported TCA on receipt of the initial emergency call. Patients were subsequently excluded if a medical cause of cardiac arrest was suspected.

Outcome measures

Patient records were analysed for actual presence of cardiac arrest, pre-hospital resuscitation procedures undertaken and for survival to hospital rates.

Results

112 patients were reported to be in TCA on receipt of the 999/112 call. 51 (46%) were found not to be in TCA on arrival of emergency medical services. Of the 'not in TCA cohort' 34 (67%) received at least one advanced pre-hospital medical intervention (defined as emergency anaesthesia, thoracostomy, blood product transfusion or resuscitative thoracotomy). Of the 61 patients in actual TCA, 10 (16%) achieved ROSC. In 45 (88%) patients, the HEMS team escorted the patient to hospital.

Conclusion

A significant proportion of patients reported to be in TCA on receipt of the emergency call are not in actual cardiac arrest but are critically unwell requiring advanced pre-hospital medical intervention. Early activation of an enhanced care team to a

reported TCA call allows appropriate advanced resuscitation. Further research is warranted to determine which interventions contribute to improved TCA survival.

Trial Registration: N/A

Article Summary

This study shows that correct bystander recognition of cardiac arrest following a traumatic incident is poor, with many of the patients suspected to be in cardiac arrest actually having life-threatening injuries, requiring emergency medical intervention. Whilst the number of patients within this study is relatively small, the results are important for emergency medical systems.

- Bystander recognition of traumatic cardiac arrest is inaccurate.
- Patients reported to be traumatic cardiac arrest often have critical injuries, requiring pre-hospital clinical intervention.
- Activation of Helicopter Emergency Medical Services (HEMS) to reported traumatic cardiac arrest cases is encouraged.

Introduction

Major trauma is the leading cause of death in young adults worldwide. Historical observational studies report survival rates from traumatic cardiac arrest (TCA) being between 0% - 2.3%[1]. Although this mortality rate is high, Sherren et al[2] suggest that resuscitation from TCA, despite common misconception, is not universally futile with recent publications suggesting more favourable survival rates[2,3]. In TCA, advanced pre-hospital medical care can bring clinical interventions such as advanced airway management, thoracostomy, resuscitative thoracotomy and blood product transfusion. These procedures are not routinely available to standard land ambulance crews and all can have a direct effect on patient outcome from TCA[4]. In order to deliver rapid advanced medical care in the pre-hospital phase, enhanced medical care teams, such as Helicopter Emergency Medical Services (HEMS) need to be dispatched early to possible TCA cases.

Emergency medical dispatch to possible TCA cases is challenging. Patients who are critically injured following trauma are often mistaken by members of the public as being in cardiac arrest when the initial emergency call is made. However, these patients can frequently be critically unwell and have a window of opportunity for lifesaving interventions. If these interventions are not performed in a timely manner, the patient may rapidly progress to traumatic cardiac arrest, and mortality subsequently increased. In order to prevent deterioration or achieve a return-of-spontaneous circulation (ROSC) following TCA, early dispatch and rapid response of HEMS teams are required.

The host NHS Ambulance Service uses the NHS Pathways (NHSP) system for 999 call assessment and prioritisation. From June 2012, immediately life threatening calls received by the Ambulance Service were split into Red 1 and Red 2 sub categories [5]. The Red 1 category includes patients with the most time critical elements reported in the 999 call, including potential cardiac arrest situations and airway obstruction where an immediate emergency response is indicated. In NHSP there are two disposition codes[6] that generate a Red 1 coded emergency incident. Unlike other Emergency Medical Dispatch systems, NHSP uses a solely symptom based approach to call assessment and does not link the outcome of the telephone assessment to a specific incident type. Therefore any patient who is reported as not breathing, choking, fitting or that is unconscious with noisy or abnormal breathing will be assigned a Red 1 code and "dispatch for potential cardiac arrest" disposition. This call subset includes trauma patients and these incidents are passed to the HEMS service as a potential traumatic cardiac arrest situation, but this is often based on the disposition code of an unconscious patient with noisy or abnormal breathing. It is therefore to be expected that a proportion of the reported TCA dispatches are actually found not to be in TCA on the arrival of the HEMS service, however this frequency remains unknown.

The Kent, Surrey and Sussex Air Ambulance Trust (KSSAAT) operates in the south east of England providing a Helicopter Emergency Medical Service (HEMS) as a paramedic-physician team, responding 24/7 from two separates bases. The KSSAAT HEMS service provides enhanced pre-hospital medical care to south east England, a static population of approximately 4.3 million and a transient population of up to a total of 10 million. This area consists of both urban and rural areas and is

served by Major Trauma centres in London, Brighton and Southampton (22). Patient transport to hospital can be by air or road, depending on geography, weather, time of day and hospital helipad availability. On average, patients are 44 km in linear distance from incident scene to receiving hospital and have an average primary transfer time of 30 minutes to hospital by air or road. The maximum road transfer time is approximately 1 hour 45 minutes from the furthest geographical point of the region. Statistics from The National Audit Office suggest that in this region of the UK, there are approximately 630 cases of major trauma annually. The primary response is by helicopter or rapid response car when the helicopter is offline for maintenance or weather. As well as the speed of reaching these patients, additional advanced clinical interventions are brought to the scene by the HEMS team. These include, but are not limited to, rapid sequence induction (RSI) of anaesthesia, simple and tube thoracostomy insertion, resuscitative thoracotomy, emergency hysterotomy, blood product transfusion, emergency reversal of anti-coagulation, and maxillofacial packing. The immediate dispatch criteria of a HEMS team are standardised. One immediate dispatch criterion is major trauma and / or traumatic cardiac arrest (TCA) as evidenced during the initial emergency call description. Interrogation of the call is performed by call handlers who are traditionally not medically trained personnel. Accurately evaluating which patients are in actual or impending TCA from the initial emergency call is crucial if the correct emergency medical response is to be activated.

The aim of this study is to describe the cohort of patients reported to be in TCA on receipt of the initial emergency call to South East Coast Ambulance Service NHS Foundation Trust (SECAmb). It was hypothesised that many patients who were

reported during the emergency call to be in TCA may not be in actual cardiac arrest, but could be in a critical condition requiring rapid advanced medical intervention. This study describes this patient demographic, interventions performed and survival to hospital.

Methods

A retrospective database analysis of patient demographics, clinical care and outcome was performed. Patients reported to be in TCA between 01/07/2016 – 31/12/2016 within the trust's geographical region were identified and studied from the local ambulance trust's electronic patient database. The inclusion criteria were all cases of reported TCA on receipt of the initial emergency call. Patients were subsequently excluded if a medical cause of cardiac arrest was suspected. The clinical records of all cases were examined and patient demographics, physiological state, clinical interventions and return of spontaneous circulation analysed.

Outcome measures

The outcome measures included the proportion of patients initially reported as being in TCA who were subsequently found not to be in cardiac arrest; the rate of HEMS clinical interventions in this patient cohort and survival to reach hospital.

HEMS advanced interventions were defined as clinical interventions that a land-based ambulance crew would not be able to perform. These included RSI, surgical chest decompression (thoracostomy), transfusion of blood products and resuscitative thoracotomy. Simple interventions were defined as those that could be performed by a UK registered paramedic. Whether the patient was transported to hospital, the

transport means (land ambulance versus helicopter) and whether the HEMS crew was required to accompany the patient were also noted.

Patient and Public Involvement

This study question was raised, as the outcome from traumatic cardiac arrest remains very poor, with few patients surviving to reach discharge from hospital. Several patients visiting Kent, Surrey & Sussex Air Ambulance expressed support for the Trust to undertake research in the is domain. As well as publication, we plan to disseminate our results via the South East Coast Ambulance Service Research & Development Committee, which includes patient representatives.

Data

Data was extracted from KSSAAT's bespoke database (HEMSbase, MedicOne Systems Ltd, UK) and analysed on Microsoft Excel (Microsoft Corporation, USA). This study met National Institute for Healthcare Research criteria for a service evaluation and was registered with the University of Surrey.

Results

The database review found 160 patients that were reported as being in 'cardiac arrest' on receipt of the 999/112 emergency call. Of these, 48 (30%) were subsequently found to be primary medical arrests and were therefore excluded. This left 112 patients being reported from the 999 call as being in TCA.

On arrival of land ambulance crews and/or the HEMS team, 61 (54%) were found to be in actual cardiac arrest. Of the 112 patients reported to be in TCA, 51 (46%) had spontaneous circulation on arrival of the first emergency medical services. Patient inclusion is shown in Figure 1.

Pre-hospital clinical interventions

Following arrival of emergency medical services, the pre-hospital clinical interventions administered to the patient were reviewed. 'Routine' and 'HEMS' interventions are shown in Table 1.

Table 1. Pre-hospital clinical interventions

Routine Interventions	**HEMS Interventions**
Patient packaging & Immobilisation	Rapid Sequence Induction of anaesthesia
Limb Splintage	Blood product transfusion
Basic Airway Management	Thoracostomy
Intravenous access	Resuscitative thoracotomy
Intraosseous access	
External haemorrhage control	
Pelvic Splintage	

Of the patients not found to be in TCA (n=51), a significant proportion (n=42, 82%) required advanced clinical intervention from the attending HEMS team. The number of included patients who received each of the HEMS advanced interventions is shown in Table 2.

Table 2. Helicopter Emergency Medical Services clinical interventions performed in patients with spontaneous circulation who had initially been reported to be in traumatic cardiac arrest

Intervention	Number of Patients
RSI	26
Blood product transfusion	16
Thoracostomy	14
Resuscitative thoracotomy	0

The total number of HEMS interventions each individual patient received from the HEMS team is shown in Table 3.

Table 3. Total number of Helicopter Emergency Medical Service interventions performed in patients with spontaneous circulation who had initially been reported to be in traumatic cardiac arrest.

Number of HEMS interventions performed	Number of patients
1	19
2	16
3	7
4	0

Patients with cardiac output on arrival of HEMS

The majority of patients found to have spontaneous circulation required a HEMS escort to hospital. In 24 (41%) cases the patient was escorted in a land ambulance; in 21 (41%) cases transported via helicopter and 5 (10%) transported unescorted by the HEMS team with a land ambulance crew. In one case a patient who initially had spontaneous circulation suffered a cardiac arrest in the presence of the HEMS crew and was subsequently pronounced life extinct at scene.

Patient outcome

Of the 51 patients initially reported to be in TCA who had spontaneous cardiac output on first EMS arrival, 50 (98%) survived to hospital admission.

Out the patients found to be in actual TCA (n=61), pre-hospital ROSC was achieved in 10 (16%), with all these patients surviving to reach hospital.

Discussion

This study found that 46% of patients who were reported by the bystander on scene to be in TCA following a serious accident, actually had spontaneous circulation on arrival of emergency medicine services. This group of patients had a very high likelihood of needing advanced pre-hospital clinical intervention, with 82% of patients who were not in actual TCA requiring one or more clinical interventions from the attending HEMS team. Previous studies have suggested that resuscitation from traumatic cardiac arrest has been historically perceived as futile[7]. A risk exists, therefore, that advanced emergency medical services, such as HEMS, will not be dispatched immediately following receipt of a suspected TCA call. As this study has demonstrated, this group of patients are at high risk of being critically injured; with a high proportion needing advanced pre-hospital clinical care. Any delay in administering advanced care, such as emergency anaesthesia, surgical chest decompression or volume resuscitation, is likely to have a detrimental effect on patient outcome. When the patient was found to be in actual TCA, clinical intervention from the HEMS team resulted in a ROSC rate of 16%. It would therefore appear prudent to task advanced emergency medical services immediately.

The ability of a layperson to inaccurately diagnose cardiac arrest is well recognised [8,9]. Accurately diagnosing cardiac arrest following trauma is known to be particularly problematic. Following a traumatic incident, such as a serious road traffic collision, there is often a high degree of emotion and anxiety. The caller themselves may have been involved in the accident, may be a friend or relative of the critical patient, or may themselves be injured. The ability of a bystander at the scene of a suspected

traumatic cardiac arrest to make an accurate assessment may therefore be hampered.

Previous studies[10] have shown the benefit of HEMS intervention for traumatic cardiac arrest. Current guidelines advocate a standard, systematic approach to resuscitation from TCA[4]. Some elements of the resuscitation algorithm (intubation, surgical chest decompression and blood product administration) can only be performed by advanced care providers and in some systems these interventions are limited to physicians. The outcome benefit of specific pre-hospital clinical interventions in major trauma remains the subject of on-going research. Early pre-hospital anaesthesia has been shown to improve outcome in blunt neurotrauma[11]. In order to maximise the chance of patient survival, these interventions need to be performed as early as possible, if ROSC is to be achieved. This requires pre-hospital intervention, with early, accurate identification of the critical medical need at the point of receiving the emergency phone call

This study has several limitations. The time period for case review was relatively limited, however the total number of patients included was felt to be reasonable. It was not possible to analyse exact ambulance dispatch system entries to look for specific patterns of recognition of TCA. In particular, it was not possible to analyse the exact voice recordings of the emergency call. Voice call analysis has previously been shown to be valuable in examining telephone recognition of cardiac arrest and would be a valuable area for future research to establish whether specific triggers can inform appropriate resource dispatch to potential cardiac arrest cases[9]. Other

future research could involve the live transmission of mobile phone visual footage from scene to assist in trauma dispatch and patient assessment via telephone.

Conclusion

A significant proportion of major trauma patients reported to be in TCA on receipt of the initial emergency call are not in actual cardiac arrest but are critically unwell requiring advanced pre-hospital medical intervention. Early activation of an enhanced care team to a reported TCA call allows appropriate advanced resuscitation to occur in the pre-hospital phase and maximises the patient's chances of meaningful survival. Further research is warranted to determine which pre-hospital clinical interventions contribute to improved TCA survival.

Declarations

Ethics

This study met UK National Institute for Health Research criteria for a service evaluation. All the data utilised for this study was routinely collected as part of standard pre-hospital and hospital patient data collection. Formal ethical approval was therefore waived as criteria for service evaluation were met. The study was registered with the University of Surrey as a service evaluation.

Consent for publication

Not applicable.

Availability of Data and Material

All data generated or analysed during this study are included in this published article

Competing interests funding

CP, JJ, JW, RDC and RL are all employees of Kent, Surrey & Sussex Air Ambulance Trust. There were no other financial or non-financial conflicts of interest.

Funding

No funding was received for this study

Authors' contributions

CP and JJ were involved in data collation and analysis. Data was reviewed by CP, JJ, JW, RDC and RL. Data analysis was reviewed by JW, JJ and RL. All authors were involved with preparation of the manuscript. All authors approved the manuscript prior to submission.

Acknowledgements

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Figure Legend

Figure 1. Patient Inclusion

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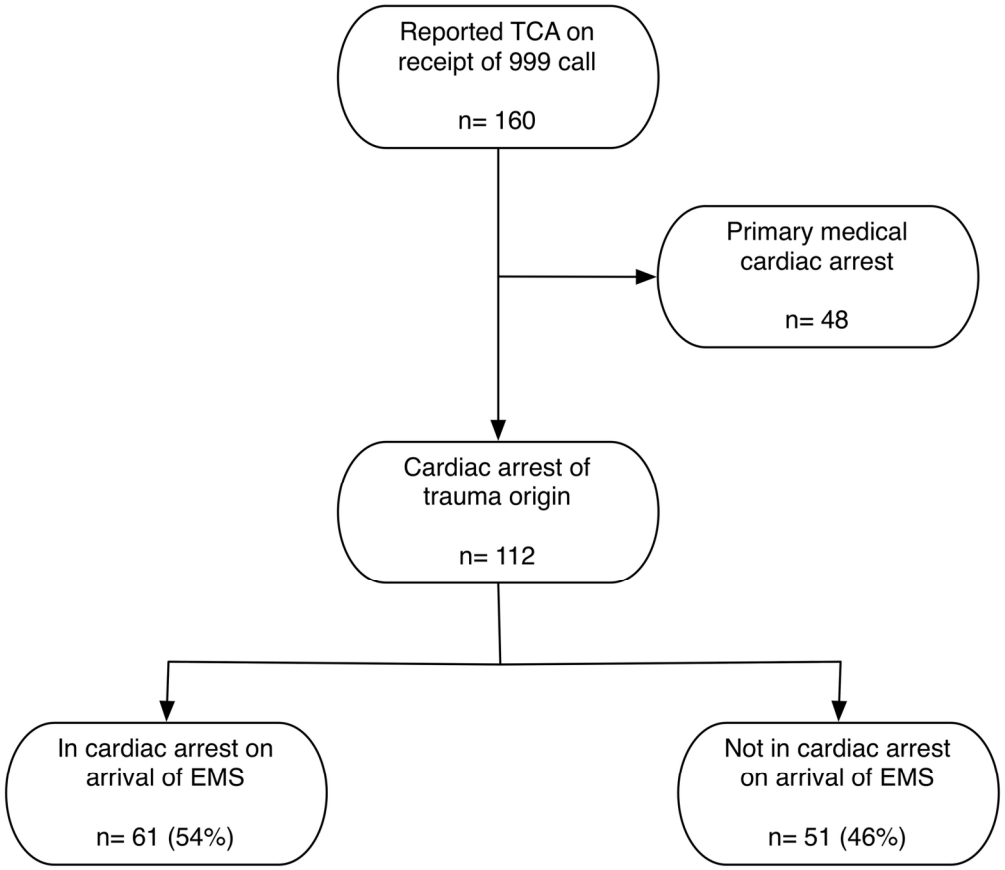
Figure Legend

Figure 1. Patient Inclusion diagram



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Key Words: trauma, emergency medical services, cardiac arrest, dispatch

Word Count: 3,007

Abstract

Objectives

The aim of this study is to describe the demographics of reported traumatic cardiac arrest (TCA) victims, pre-hospital resuscitation and survival to hospital rate.

Setting

Helicopter Emergency Medical Service in southeast England, covering a resident population of 4.5 million and a transient population of up to 8 million people.

Participants

Patients reported on the initial 999 call to be in suspected traumatic cardiac arrest between 01/07/2016 and 31/12/2016 within the trust's geographical region were identified. The inclusion criteria were all cases of reported TCA on receipt of the initial emergency call. Patients were subsequently excluded if a medical cause of cardiac arrest was suspected.

Outcome measures

Patient records were analysed for actual presence of cardiac arrest, pre-hospital resuscitation procedures undertaken and for survival to hospital rates.

Results

112 patients were reported to be in TCA on receipt of the 999/112 call. 51 (46%) were found not to be in TCA on arrival of emergency medical services. Of the 'not in TCA cohort' 34 (67%) received at least one advanced pre-hospital medical intervention (defined as emergency anaesthesia, thoracostomy, blood product transfusion or resuscitative thoracotomy). Of the 61 patients in actual TCA, 10 (16%) achieved ROSC. In 45 (88%) patients, the HEMS team escorted the patient to hospital.

Conclusion

A significant proportion of patients reported to be in TCA on receipt of the emergency call are not in actual cardiac arrest but are critically unwell requiring advanced pre-hospital medical intervention. Early activation of an enhanced care team to a

reported TCA call allows appropriate advanced resuscitation. Further research is warranted to determine which interventions contribute to improved TCA survival.

Trial Registration: N/A

Strengths and limitations

Strengths of this study

- This study is unique and one of the first to report on the specific critical issue of bystander recognition of cardiac arrest following trauma.
- The results of this study have direct implications for the pre-hospital tasking of trauma teams.
- Implementing the conclusion of this study - that early, accurate tasking of trauma teams to reported traumatic cardiac arrest is warranted, could save many lives.

Limitations of this study

- The study is retrospective and further, prospective research is warranted in this area.
- The external validity of this study remains to be fully assessed and further research is warranted in other emergency medical services.

Introduction

Major trauma is the leading cause of death in young adults worldwide (National Audit Office, 2010)[1]. Historical observational studies report survival rates from traumatic cardiac arrest (TCA) being between 0% - 2.3%[2,3]. The mortality rate from TCA is high[4,5]. Sherren et al. (2013) suggest that resuscitation from TCA, despite common misconception, is not universally futile with recent publications suggesting more favourable survival rates[5,6].

In TCA, advanced pre-hospital medical care can bring clinical interventions such as advanced airway management, thoracostomy, resuscitative thoracotomy and blood product transfusion[7-9]. These procedures are not routinely available to standard land ambulance crews and all can have a direct effect on patient outcome from TCA[8]. In order to deliver rapid advanced medical care in the pre-hospital phase, enhanced medical care teams, such as Helicopter Emergency Medical Services (HEMS) need to be dispatched early to possible TCA cases[10,11].

Emergency medical dispatch to possible TCA cases is challenging[12,13]. Patients who are critically injured following trauma are often mistaken by members of the public as being in cardiac arrest when the initial emergency call is made. However, these patients can frequently be critically unwell and have a window of opportunity for lifesaving interventions. If these interventions are not performed in a timely manner, the patient may rapidly progress to traumatic cardiac arrest, and mortality subsequently increased[5]. In order to prevent deterioration or achieve a return-of-spontaneous circulation (ROSC) following TCA, early dispatch and rapid response of HEMS teams are required[13].

The host NHS Ambulance Service uses the NHS Pathways System for 999 call assessment and prioritisation[14]. Immediately life-threatening calls received by the Ambulance Service were split into Red 1 and Red 2 sub categories. The Red 1 category includes patients with the most time critical elements reported in the 999 call. In NHSP there are two disposition codes that generate a Red 1 coded emergency incident. Any patient who is reported as not breathing, choking, fitting or that is unconscious with noisy or abnormal breathing will be assigned a Red 1 code and "dispatch for potential cardiac arrest" disposition. This call subset includes trauma patients and these incidents are passed to the HEMS service as a potential traumatic cardiac arrest situation. It is therefore to be expected that a proportion of the reported TCA dispatches are actually found not to be in TCA on the arrival of the HEMS service.

The aim of this study is to describe the cohort of patients reported to be in TCA on receipt of the initial emergency call to South East Coast Ambulance Service NHS Foundation Trust (SECAmb). It was hypothesised that many patients who were reported during the emergency call to be in TCA may not be in actual cardiac arrest, but could be in a critical condition requiring rapid advanced medical intervention. This study describes this patient demographic, interventions performed and survival to hospital.

Methods

A retrospective database analysis of patient demographics, clinical care and outcome was performed. Patients reported to be in TCA between 01/07/2016 and

31/12/2016 within the Trust's geographical region were identified and studied from the local ambulance trust's electronic patient database. The inclusion criteria were all cases of reported TCA on receipt of the initial emergency call. Patients were subsequently excluded if a medical cause of cardiac arrest was suspected. The clinical records of all cases were examined and patient demographics, physiological state, clinical interventions and return of spontaneous circulation analysed.

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Accurately evaluating which patients are in actual or impending TCA from the initial emergency call is crucial if the correct emergency medical response is to be activated.

Outcome measures

The outcome measures included the proportion of patients initially reported as being in TCA who were subsequently found not to be in cardiac arrest; the rate of HEMS clinical interventions in this patient cohort and survival to hospital.

HEMS advanced interventions were defined as clinical interventions that a land-based ambulance crew would not be able to perform. These included RSI, surgical chest decompression (thoracostomy), transfusion of blood products and resuscitative thoracotomy. Routine interventions were defined as those that could be performed by a UK registered paramedic. Whether the patient was transported to hospital, the transport means (land ambulance versus helicopter) and whether the HEMS crew was required to accompany the patient were also noted.

Patient and Public Involvement

This study question was raised, as the outcome from traumatic cardiac arrest remains very poor, with few patients surviving to reach discharge from hospital. Several patients visiting KSSAAT expressed support for the Trust to undertake research in this domain. As well as publication, we plan to disseminate our results via the South East Coast Ambulance Service Research & Development Committee, which includes patient representatives.

Data

Data was extracted from KSSAAT's bespoke database (HEMSbase, MedicOne Systems Ltd, UK) and analysed on Microsoft Excel (Microsoft Corporation, USA). This study met National Institute for Healthcare Research criteria for a service evaluation and was registered with the University of Surrey, as such formal ethical approval for a service evaluation was not required and waived.

Results

The database review found 160 patients that were reported as being in 'cardiac arrest' on receipt of the 999/112 emergency call. Of these, 48 (30%) were subsequently found to be primary medical arrests and were therefore excluded. This left 112 patients being reported from the 999 call as being in TCA.

On arrival of land ambulance crews and/or the HEMS team, 61 (54%) were found to be in actual cardiac arrest. Of the 112 patients reported to be in TCA, 51 (46%) had spontaneous circulation on arrival of the first emergency medical services. The demographic details of these 51 casualties are presented in Table 1a,b and c. Patient inclusion is shown in Figure 1.

Table 1 Demographics of the 51 patients with spontaneous circulation who had initially been reported to be in traumatic cardiac arrest,

1a Gender demographics;

1b Age Ranges;

1c Pulse status on primary assessment as a marker of injury severity

1a

Male	Female
31	20

1b

Age Range	Number
0-4	1
5-9	1
10-19	2
20-29	12
30-39	5
40-49	7
50-59	7
60-69	5
70-79	7
80-89	4
90-99	

1c

Pulse Status on Primary Assessment	Number
Radial Pulse	43
Femoral Pulse	4
Carotid Pulse	4

Pre-hospital clinical interventions

Following arrival of emergency medical services, the pre-hospital clinical interventions administered to the patient were reviewed. 'Routine' and 'HEMS' interventions are shown in Table 2.

Table 2. Pre-hospital clinical interventions

Routine Interventions	**HEMS Interventions**
Patient packaging & Immobilisation	Rapid Sequence Induction of anaesthesia
Limb Splintage	Blood product transfusion
Basic Airway Management	Thoracostomy
Intravenous access	Resuscitative thoracotomy
Intraosseous access	
External haemorrhage control	
Pelvic Splintage	

Of the patients not found to be in TCA (n=51), a significant proportion (n=42, 82%) required advanced clinical intervention from the attending HEMS team. The number of included patients who received each of the HEMS advanced interventions is shown in Table 3.

Table 3. Helicopter Emergency Medical Services clinical interventions performed in patients with spontaneous circulation who had initially been reported to be in traumatic cardiac arrest

Intervention	Number of Patients
RSI	26
Blood product transfusion	16
Thoracostomy	14
Resuscitative thoracotomy	0

The total number of HEMS interventions each individual patient received from the HEMS team is shown in Table 4.

Table 4. Total number of Helicopter Emergency Medical Service interventions performed in patients with spontaneous circulation who had initially been reported to be in traumatic cardiac arrest

Number of HEMS interventions performed	Number of patients
1	19
2	16
3	7
4	0

Patients with cardiac output on arrival of HEMS

The majority of patients found to have spontaneous circulation required a HEMS escort to hospital. In 24 (47%) cases the patient was escorted in a land ambulance; in 21 (41%) cases transported via helicopter and 5 (10%) transported unescorted by the HEMS team with a land ambulance crew. In one case a patient who initially had spontaneous circulation suffered a cardiac arrest in the presence of the HEMS crew and was subsequently pronounced life extinct at scene.

Patient outcome

Of the 51 patients initially reported to be in TCA who had spontaneous cardiac output on first EMS arrival, 50 (98%) survived to hospital admission. Out of the patients found to be in actual TCA (n= 61), pre-hospital ROSC was achieved in 10 (16%), with all these patients surviving to reach hospital.

Discussion

This study found that 46% of patients who were reported by the bystander on scene to be in TCA following a serious accident, actually had spontaneous circulation on arrival of emergency medicine services. This group of patients had a very high likelihood of needing advanced pre-hospital clinical intervention, with 82% of patients who were not in actual TCA requiring one or more clinical interventions from the attending HEMS team.

Previous studies have suggested that resuscitation from TCA has been historically perceived as futile[3,15]. A risk exists, therefore, that advanced emergency medical services, such as HEMS, will not be dispatched immediately following receipt of a suspected TCA call. As this study has demonstrated, this group of patients are at high risk of being critically injured; with a high proportion needing advanced pre-hospital clinical care. Any delay in administering advanced care, such as emergency anaesthesia, surgical chest decompression or volume resuscitation, is likely to have a detrimental effect on patient outcome[1,16]. When the patient was found to be in actual TCA, clinical intervention from the HEMS team resulted in a ROSC rate of 16%. It would therefore appear prudent to task advanced emergency medical services immediately.

The ability of a layperson to inaccurately diagnose cardiac arrest is well recognised[11,17]. Accurately diagnosing cardiac arrest following trauma is known to be particularly problematic. Following a traumatic incident, such as a serious road traffic collision, there is often a high degree of emotion and anxiety. The caller themselves may have been involved in the accident, may be a friend or relative of the critical

patient, or may themselves be injured[13]. The ability of a bystander at the scene of a suspected traumatic cardiac arrest to make an accurate assessment may therefore be hampered[1]. Whilst the current early dispatch of HEMS is based on essentially a symptom-based system, other potential factors could be incorporated to help this for example the mechanism of incident or injury, the nature and severity for example high speed road traffic accident, roll-over and entrapped casualties.

Previous studies have shown the benefit of HEMS intervention for TCA[6,7]. Current guidelines advocate a standard, systematic approach to resuscitation from TCA[8]. Some elements of the resuscitation algorithm (intubation, surgical chest decompression and blood product administration) can only be performed by advanced care providers and in some systems these interventions are limited to physicians. The outcome benefit of specific pre-hospital clinical interventions in major trauma remains the subject of on-going research. Early pre-hospital anaesthesia has been shown to improve outcome in blunt neurotrauma[18]. In order to maximise the chance of patient survival, these interventions need to be performed as early as possible, if ROSC is to be achieved[1]. This requires pre-hospital intervention, with early, accurate identification of the critical medical need at the point of receiving the emergency phone call.

Limitations

This study has several limitations. The time period (01/07/2016 – 31/12/2016) for case review was relatively limited, however the total number of patients included was felt to be reasonable. It was not possible to analyse exact ambulance dispatch system entries to look for specific patterns of recognition of TCA. In particular, it was

not possible to analyse the exact voice recordings of the emergency call. Voice call analysis has previously been shown to be valuable in examining telephone recognition of cardiac arrest and would be a valuable area for future research to establish whether specific triggers can inform appropriate resource dispatch to potential cardiac arrest cases[19]. Other future research could involve the live transmission of mobile phone visual footage from scene to assist in trauma dispatch and patient assessment via telephone.

Conclusion

A significant proportion of major trauma patients reported to be in TCA on receipt of the initial emergency call are not in actual cardiac arrest but are critically unwell requiring advanced pre-hospital medical intervention. Early activation of an enhanced care team to a reported TCA call allows appropriate advanced resuscitation to occur in the pre-hospital phase and maximises the patient's chances of meaningful survival. Further research is warranted to determine which pre-hospital clinical interventions contribute to improved TCA survival.

Declarations

Ethics

This study met UK National Institute for Health Research criteria for a service evaluation. All the data utilised for this study was routinely collected as part of standard pre-hospital and hospital patient data collection. Formal ethical approval was therefore waived as criteria for service evaluation were met. The study was registered with the University of Surrey as a service evaluation.

Consent for publication

Not applicable.

Availability of Data and Material

All data generated or analysed during this study are included in this published article

Competing interests funding

CP, JJ, JW, RDC and RL are all employees of Kent, Surrey & Sussex Air Ambulance Trust. There were no other financial or non-financial conflicts of interest.

Funding

No funding was received for this study

Authors' contributions

CP and JJ were involved in data collation and analysis. Data was reviewed by CP, JJ, JW, RDC and RL. Data analysis was reviewed by JW, JJ and RL. All authors were involved with preparation of the manuscript. All authors approved the manuscript prior to submission.

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Figure Legend

Figure 1. Patient inclusion; TCA, traumatic cardiac arrest; EMS, Emergency Medical Services.

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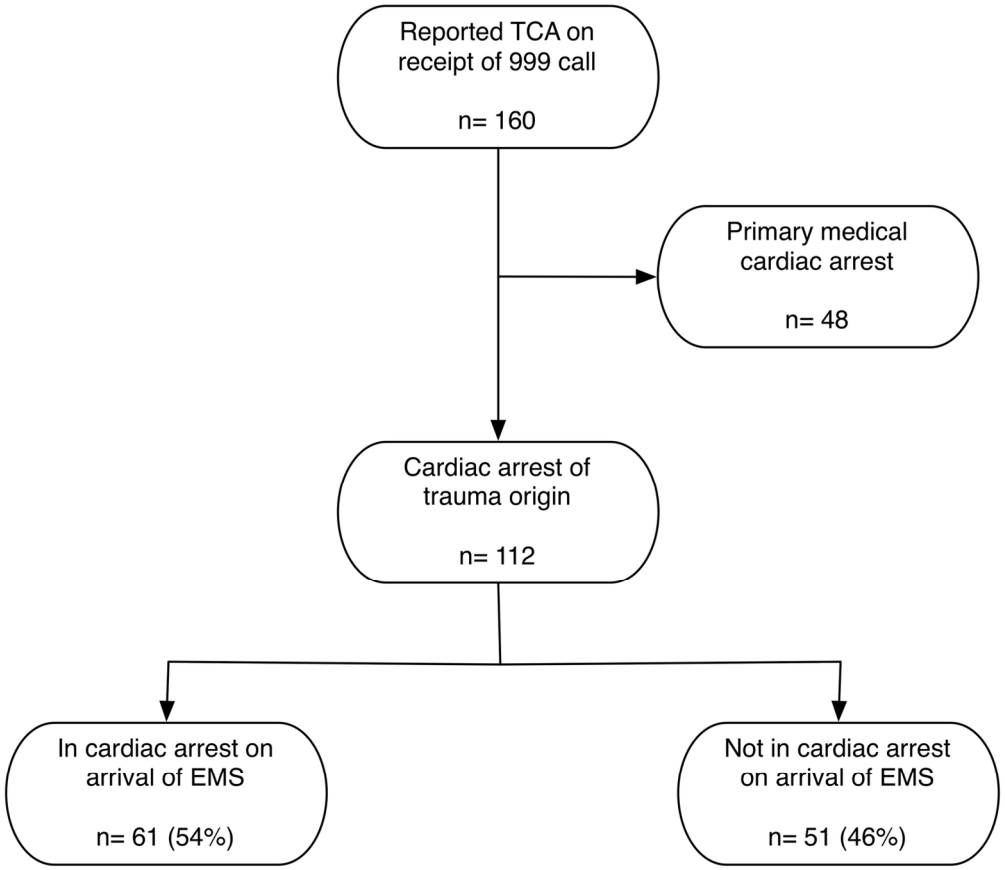

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract – P1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found – P2
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported – P4
Objectives	3	State specific objectives, including any prespecified hypotheses – P5
Methods		
Study design	4	Present key elements of study design early in the paper – P6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection P6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants P6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable P7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group P8
Bias	9	Describe any efforts to address potential sources of bias P8
Study size	10	Explain how the study size was arrived at P8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why P8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding P8
		(*b*) Describe any methods used to examine subgroups and interactions N/A
		(*c*) Explain how missing data were addressed P9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy N/A
		(*e*) Describe any sensitivity analyses N/A
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed p11
		(b) Give reasons for non-participation at each stage N/A
		(c) Consider use of a flow diagram p11
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Table 1
		(b) Indicate number of participants with missing data for each variable of interest P8 and tables
Outcome data	15*	Report numbers of outcome events or summary measures P10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included N/A

		(*b*) Report category boundaries when continuous variables were categorized N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses P10
Discussion		
Key results	18	Summarise key results with reference to study objectives P15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias P16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence P15
Generalisability	21	Discuss the generalisability (external validity) of the study results P17
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based P18

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.