ORIGINAL ARTICLE

Emergency treatment for traumatic cardiac arrest: prognostic factors and hospital outcome

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Objective. To identify prehospital and on-arrival factors associated with hospital outcome in patients with traumatic cardiac arrest (TCA) discharged with recovered spontaneous circulation from the emergency department.

Material and methods. Multipurpose prospective cohort study of patients with TCA who recovered after treatment at a tertiary care hospital emergency department between 2003 and 2016. We gathered data on epidemiologic variables, type and cause of injuries, and prehospital and hospital emergency care. The outcome was overall hospital mortality.

Results. A total of 130 TCA cases were included; 123 patients (94.6%) had received blunt trauma injuries and 65 (50%) had been in traffic accidents. The mean (SD) age was 39 (16) years, and 96 (73.8%) were male. Fifty patients (65%) were in asystole and 42 (32.3%) had pulseless electrical activity. Sixteen (12.3%) survived to be discharged; 13 of the survivors (81.3%) had recovered neurological activity. Factors that were independently associated with hospital mortality were asystole on arrival of first responders (odds ratio [OR], 25; 95% CI, 2.5–247; *P*=.006), nonreactive pupils on arrival at the hospital (OR, 13; 95% CI, 2.0–79; *P*=.006), and an Injury Severity Score over 25 (OR, 13; 95% CI, 1.8–94; *P*=.011).

Conclusions. Twelve percent of patients in this cohort survived to discharge after TCA and 8 out of 10 of the surviving patients recovered neurologically. Asystole at start of prehospital care, nonreactive pupils on hospital arrival, and a severity score over 25 may indicate poor prognosis after TCA.

Keywords: Heart arrest, traumatic. Cardiopulmonary resuscitation. Advanced life support. Emergency medical services.

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Factores pronóstico y resultados intrahospitalarios de la parada cardiaca traumática atendida en un servicio de urgencias

Objetivo. Identificar los factores pronóstico a la llegada a urgencias y los resultados al alta hospitalaria de los pacientes en parada cardiaca traumática (PCT), documentada por un servicio de emergencias médicas (SEM), con posterior recuperación de la circulación espontánea (RCE).

Método. Estudio de cohorte multipropósito de pacientes con PCT recuperada atendidos en un servicio de urgencias (SU) de un hospital universitario de tercer nivel de 2003 a 2016. Se recogieron variables epidemiológicas, tipo y mecanismo del traumatismo, datos de la atención extrahospitalaria y del SU. La variable de resultado fue la mortalidad global intrahospitalaria.

Resultados. Se incluyeron 130 PCT, de los cuales 123 (94,6%) sufrieron un traumatismo cerrado y 65 (50%) tuvieron un accidente de tráfico. La edad media fue de 39 (DE 16) años y 96 (73,8%) fueron varones. Cincuenta pacientes (65%) presentaron asistolia y 42 (32,3%) actividad eléctrica sin pulso (AESP). Dieciséis (12,3%) sobrevivieron al alta, de los cuales 13 (81,3%) tuvieron recuperación neurológica favorable. Un ritmo de asistolia en la primera atención de extrahospitalaria (OR = 25; IC 95% 2,5-247; p = 0,006), las pupilas arreactivas a la llegada al hospital (OR = 13; IC 95% 2,0-79; p = 0,006), y una puntuación > 25 de la *Injury Severity Score* (ISS) (OR = 13; IC 95% 1,8-94; p = 0,011) se asociaron de forma independiente con la mortalidad intrahospitalaria.

Conclusión. En nuestra serie, la supervivencia intrahospitalaria de la PCT fue un 12% siendo la recuperación neurológica favorable en ocho de cada diez vivos. El ritmo inicial en asistolia en la atención extrahospitalaria, la pupilas arreactivas a la llegada al hospital y una puntuación > 25 de ISS podrían implicar un mal pronóstico.

Palabras clave: Parada cardiaca traumática. Resucitación cardiopulmonar. Soporte vital avanzado. Servicios de emergencia médica.

Introduction

Traumatic cardiac arrest (TCA) has been conceived for decades as a clinical situation associated with heroic efforts with high mortality, poor neurological prognosis and high costs, with cardiopulmonary resuscitation (CPR) being considered a futile maneuver[1-3]. In 2006, Willis et al.[4] reassessed this premise by collecting a survival rate of 4.3% in their sample, confirming hopeful results with hospital discharge survivors ranging from 5%-8%[5-8].

On the other hand, the functional prognosis of these patients has been described as poor, although it also presents a progressive tendency towards a subsequent positive evolution, reaching a favourable neurological recovery (FNR), understood as complete or slight deterioration of the same, from a 2% to 10%[7-9]. Therefore, the current European CPR guides for 2015 maintain the premise about the poor prognosis of the TCA. However, as a novelty, they warn about better FNR rates than those patients who suffer from cardiorespiratory arrest (CRA) of medical cause, motivating the incorporation of a new management algorithm for TCA[10].

The criteria for not initiating or abandoning CPR manoeuvres in TCA have also been included in these guidelines. However, the identification of factors associated with increased survival in patients who achieve restoration of spontaneous circulation (ROSC) remains unclear and have not been described with certainty. In addition, there are conditioning factors that could influence both predictors and TCA outcomes, such as: the actual timing of the CRA, the frequency of injuries and type of trauma characteristic of each country, or different models of prehospital care, as well as their competencies.

Therefore, given the limited literature on TCA in Spain[7], the objective of this study was to identify the variables associated with poor prognosis on arrival, and the vital and neurological prognosis of patients with TCA documented by the health service. Emergency medical service (EMS), with ROSC, attended at an emergency department (ED) of a university hospital of third level.

Method

A multipurpose cohort study was carried out from a registry with data collection prospectively from February 2003 to February 2016 carried out in an ED of a university hospital of high complexity of the Community of Madrid (Spain). Once the EMS had been given notice of the arrival of the patient with severe trauma (ST), the hospital reception occurred directly from the ambulance or helicopter to the resuscitation box of the ED.

We included patients who were older than 18 years who suffered a TCA, with a score of zero according to the Revised Trauma Score (RTS) at the time of the first assessment by the EMS and with ROSCs in situ, who were later referred to our center with verbal diagnosis and written CRA report by the EMS. Patients with medical CPR with secondary trauma were excluded or if CRA occurred during initial outpatient care or hospital transfer.

Demographic variables (age and sex), trauma type and mechanism, out-of-hospital care data (initial TCA rhythm, CPR time and hospital arrival, type of helicopter or ambulance transport, and administered fluids), attention given at the ED (blood pressure, heart rate and frequency, pupillary reactivity, volume of blood transfused if necessary, procedures, anatomical lesions using the Abbreviated Injury Score -AIS- and severity of the same through Injury Severity Score -ISS-), and outcome (length of stay in intensive care unit -ICU-, survival and neurological status at discharge). Neurological status was assessed using the Glasgow Outcome Scale (GOS), and FNR patients were classified as having good recovery or moderate disability (GOS 5-4), or poor neurological prognosis if they had severe disability or persistent coma (GOSE 3- 2).

Regarding the statistical analysis, the quantitative variables were described as mean and standard deviation or median and interquartile range (IQR). The hypothesis test of these variables was made by the Student t test if the distribution was normal and the Mann Whitney U test if the principle of normality was not observed according to Kolmogorov Smirnov test. The qualitative variables were shown by frequency in absolute value and corresponding percentage. The association between them was analysed by chi-square test or Fisher's test as appropriate. A multivariate analysis was performed using logistic regression, using as a dependent variable the hospital evolution to identify independent predictors of in-hospital mortality, calculating the odds ratio (OR) and its 95% confidence interval (95% CI), with internal validation using a technique of bootstrapping. Statistical significance was considered throughout the analysis when $p < 0.05$. Statistical analysis was performed with SPSS software version 22.0 (IBM SPSS, Armonk, New York, USA IBM Corp.).

Results

During the study period, 4,134 trauma patients were treated in the resuscitation box, of which 143 had a TCA diagnosis. Three patients were excluded due to secondary trauma to medical CRA and 10 patients after initial pulse and subsequent CRA were confirmed during out-of-hospital care. We finally included 130 (3.1%) patients for the present study.

Patients who suffered a TCA had a mean age of 39 (SD 16) years and were more frequently males (2.9: 1). Closed trauma occurred in 123 (94.6%) patients. The most frequent mechanism of trauma was car accident (28/130 [21.5%]), followed by run-overs (22/130 [16.9%]) and falls 20 (20/130 [15.4 %]).

Asystole and pulseless electrical activity (PEA) were present in 65 (50%) and 42 (32.3%) patients with TCA respectively on arrival at the EMS, to which 16 (12.3%) were added with a TCA diagnosis in non-defibrillable rhythm without being specified in the clinical history of the EMS itself. The median time for the ROSC was 10 (IQR 5.0-18.8) minutes. Table 1 shows the out-of-hospital care data.

On arrival at the ED, from the initial 130 patients, 7 (5.4%) required emergency thoracotomy, all of them preformed in penetrating trauma, and 35 (28.5%) were transferred to the operating room or emergency arteriography. One hundred twenty (92.3%) of the cases admitted at the ICU directly or after interventionism.

Sixteen (12.3%) survived discharge, of which 13 (81.3%) had favourable neurological recovery (Figure 1). Table 2 shows hospital care data.

The ICU stay was 0.8 days (IQR 0.08-2.0) for the deceased, in opposition to 11.9 (IQR 3,9-21,4) for the survivors (p <0.001). The most frequent causes of mortality were exsanguination (44/114 [38.6%]) and endocranial hemorrhage (43/114 [37.7%]), respectively.

Regarding the predictors of evolution, after a multivariate analysis, we found that an asystole rate on arrival at EMS (OR = 25, 95% CI: 2.5-247, p = 0.006), reactive pupils (OR = 13, 95% CI: 2.0-79, p = 0.006), and a score of > 25 points on the ISS (OR = 13, 95% CI: 1.8 94; were independently associated with in-hospital mortality (Table 3).

Table 1. Univariate analysis of out-of-hospital prognostic factors according to in-hospital mortality

	Global (N = 130) n (%)	Deceased (N = 114) n (%)	Alive (N = 16) n (%)	p
Age (years) [mean (SD)]	39.0 (15.8)	36.0 (15.4)	46 (16.0)	0.47
Male sex	96 (73.8)	85 (88.5)	11 (11.5)	0.62
Mechanism of trauma				0.164
Car	28 (21.5)	25 (21.9)	3 (18.8)	
Run over	22 (16.9)	20 (17.5)	2 (12.5)	
Fall	20 (15.4)	19 (16.7)	1 (6.3)	
Motorcycle	16 (12.3)	13 (11.4)	3 (18.8)	
Knife stab	6 (4.6)	4 (3.5)	2 (12.5)	
Drowning	6 (4.6)	4 (3.5)	2 (12.5)	
Squashed	5 (3.8)	5 (4.4)	0 (0)	
Hanging	4 (3.1)	4 (3.5)	0 (0)	
Intoxication fumes	4 (3.1)	4 (3.5)	0 (0)	
Hit with object	4 (3.1)	3 (2.6)	0 (0)	
Bicycle accident	2 (1.5)	2 (1.8)	0 (0)	
Electrocution	2 (1.5)	0 (0)	2 (12.5)	
Hypothermia	1 (0.8)	0 (0)	0 (0)	
Others	8 (6.2)	11 (9.6)	1 (6.3)	
Type of trauma				0.178
Closed	123 (94.6)	109 (88.6)	14 (11.4)	
Penetrating	7 (5.4)	5 (71.4)	2 (28.6)	
CRA-OH rhythm (N = 114)				0.004
Asystole	65 (50.0)	62 (95.4)	3 (4.6)	
PEA	42 (32.3)	31 (73.8)	11 (26.2)	
VF	7 (5.4)	5 (71.4)	2 (28.6)	
Adrenaline (N = 104) (Mg) [median (IQR)]	2 (1-3.8)	2 (1-4)	2 (1-3)	0.678
Airway management				0.401
OTI	121 (93.1)	107 (88.4)	14 (11.6)	
Fastrach	6 (4.6)	4 (66.7)	2 (33.3)	
Cricotiroidotomy	1(0.8)	1 (100)	0 (0)	
Unmanaged	2 (1.5)	2 (100)	0 (0)	
Time of CPR (N = 108) (Min) [median (IQR)]	10 (5-18.8)	10 (5-18.5)	10 (4.5-19.3)	0.426
Volume (N = 93)				0.154
No	1 (1.1)	1 (100)	0 (0)	
Yes	92 (98.9)	81(88.0)	11 (12)	
In m^3 [median (IQR)]	1.550 (1.000-2.500)	1.700 (1.000-2.500)	1.200 (500-2.200)	
Conveyance				0.228
Terrestrial ALS	88 (67.7)	80 (90.9)	8 (9.1)	
Helicopter	41 (31.5)	33 (80.5)	8 (19.5)	
Private transport	1 (0.8)	1 (100)	0 (0)	
Outpatient time (Min) [median (IQR)]	71.3 (51.5-90)	67.5 (60-90)	75 (53-105)	0.447

SD: standard deviation; CRA: cardiorespiratory arrest; OH: out-of-hospital; PEA: pulseless electrical activity; VF: ventricular fibrillation; IQR: interquartile range; OTI: orotracheal intubation; CPR: cardiopulmonary resuscitation; CC: cubic centimetres; AVS: advanced life support; Out-of-hospital time: time of care and transfer to the hospital; SD: standard deviation; IQR: interquartile range.

Table 2. Univariate analysis of prognostic factors on arrival at emergency resuscitation ward according to in-hospital mortality

	Global (N = 130) n (%)	Deceased (N = 114) n (%)	Alive (N = 16) n (%)	p
Pace in the emergency room				0.315
Sinus rhythm	94 (72.3)	80 (85.1)	14 (14.9)	
Asystole	20 (15.4)	20 (100)	0 (0)	
PEA	15 (11.5)	13 (86.7)	2 (13.3)	
FV	1 (0.8)	1 (100)	0 (0)	
SBP < 90 mmHg in emergencies (N = 125)	81 (67.5)	74 (91.4)	7 (8.6)	0.117
HR in the emergency room (bpm) (n = 120) [mean (SD)]	87.9 (45.6)	85.8 (47.4)	103.4 (22.6)	0.169
Pupils in the emergency room (N = 118)				< 0.001
Reactive	30 (25.4)	19 (61.3)	11 (38.7)	
Areactive	88 (74.6)	84 (95.5)	4 (4.5)	
AIS ≥ 3				
Head	53 (57.0)	48 (90.6)	5 (9.4)	0.022
Chest	64 (62.1)	55 (85.9)	9 (14.1)	0.597
Abdomen	19 (19.8)	18 (94.7)	1 (5.3)	0.136
Column	22 (23.4)	19 (86.4)	3 (13.6)	0.629
Extremities	25 (25.3)	21 (84.0)	4 (16.0)	0.98
ISS (N = 95) [Median (IQR)]	38 (25-54)	41 (29-57)	27 (25-37)	< 0.040
ISS ≤ 25	25 (26.3)	17 (68.0)	8 (32.0)	
ISS > 25	70 (73.7)	62 (88.6)	8 (11.4)	< 0.018
Blood (N = 125)				0.382
Do not	50 (40.0)	42 (84.0)	8 (16.0)	
Yes	75 (60.0)	67 (89.3)	8 (10.7)	
In median cc (IQR)	750 (0-2.500)	–750 (0-2.625)	125 (0-1.937)	0.836
Emergency thoracotomy	7 (5.4)	5 (71.4)	2 (28.6)	0.178
Urgent surgery (N = 128)				0.313
No	102 (79.7)	91 (89.2)	11 (10.8)	
Yes	28 (20.3)	23 (82.1)	5 (17.9)	

PEA: pulseless electrical activity; FV: ventricular fibrillation; SBP: systolic blood pressure; HR: heart rate; BPM: beats per minute; AIS: Abbreviated Injury Scale; ISS: injury Severity score; CC: cubic centimetres; SD: standard deviation; IQR: interquartile range.

Discussion

Traumatic disease continues to be a major cause of death and permanent disability in young adults[11]. Patients with TCA contribute to this, in whom care was questioned in terms of cost-effectiveness[1]. Therefore, our work focused on investigating the prognostic factors on arrival in the emergency room of patients who presented a TCA. This was the cause of 3 out of 100 trauma care, and the patients presented a profile similar to that of the patient with traumatic disease in Spain, that is, a man, middle age, who suffers a closed trauma from a traffic accident[11].

Non-defibrillating rhythms are more frequent in medical-originated CRA, with a survival rate in this subgroup of patients of 4.2% and FNR in 2.9%[12]. However,

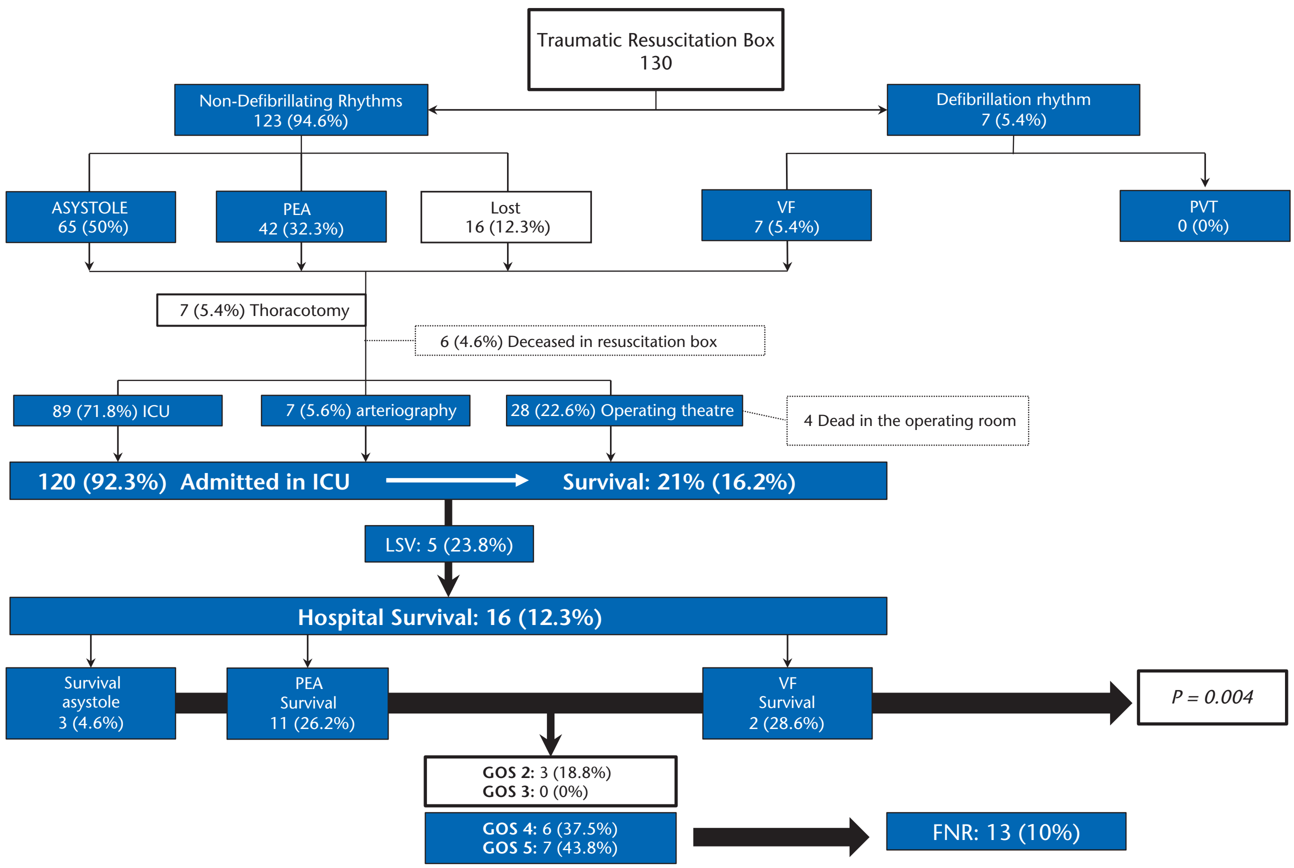

Figure 1. Hospital evolution of patients with traumatic cardiac arrest. CRA: cardiorespiratory arrest. PEA: pulseless electrical activity; VF: ventricular fibrillation; PVT: pulseless ventricular tachycardia; LSV: limitation of life support; ICU: intensive care unit; GOS: Glasgow Outcome Scale; FNR: favourable neurological recovery (GOS: 4-5).

in comparison with our TCA series, where non-defibrillatory rhythms were also the most frequent, 3 times higher survival rates were found with better FNR rates.

The presence of asystole has been described as a poor prognostic factor in the patient with trauma[13], which is in accordance with our results where it was the determinant of the greatest negative impact on survival. In contrast, 68.8% of the survivors presented an early PEA. In this context, Smith et al.[14] stated that, in the context of TCA, PEA sometimes represents a state of "pseudo-CRA" or low cardiac output, which prevents pulse detection. In these situations, the pump effect of the cardiac massage loses effectiveness, so that the identification and treatment of the cause would be a priority. To do this, early ultrasound in chest trauma is a current recommendation[15], and its incorporation into the place of care during CPR could provide information on its causes or predict prognosis, by discerning between a true PEA or a "pseudo-CRA"[16] in which, in the context of the TCA and in the light of results, efforts should be intensified.

Margolin et al.[17] associated the presence of low ISS to survival, while Pickens et al.[18] related both low ISS and the presence of pupillary reactivity after the ROSC as good prognostic factors. In the same vein, in our series the presence of an ISS > 25 was related to an unfavourable evolution. Although it is true that the time spent in calculating this score is an unhelpful tool when the patient arrives at the resuscitation box to establish a favourable evolution, it could be useful once it stabilizes. With regards to the pupil assessment, in the out-of-hospital setting this may be difficult, and it is not a variable collected even in large series[8,19] or not remembered in a high percentage of cases[18]. However, we consider it fundamental to assess on arrival at the EMS in which the environment is controlled and its presence strongly associated with greater survival.

Huber et al.[8] presented a series with similar characteristics to ours and we also found no influence on prognosis in relation to gender, age, trauma mechanism or orotracheal intubation. The presence of spontaneous breathing and Glasgow Coma Scale score > 3 after the EKR have been predictors associated with survival[18]. However, they were not included in our analysis after targeting a majority of patients under the effects of drugs received during out-of-hospital management that could affect such assessment.

Most of our patients were transported in an advanced life support ambulance, and while the times of care and arrival at the hospital by helicopter were higher, this did not result in statistically significant differences in the outcome. This could be due to the reduced geo-

Table 3. Multivariate analysis of prognostic factors in traumatic cardiac arrest on arrival at the emergency department

Independent variables	OR	95% CI	p
Age	1.0	1.0-1.1	0.068
Sex: male	6.3	0.9-45.4	0.084
Initial EKG asystole rhythm	24.8	2.5-247.2	0.006
Non-reactive pupils	12.7	2.0-79.2	0.006
ISS > 25	12.9	1.8-93.8	0.011
Sinus rhythm on hospital arrival	1.0	0.1-11.1	0.978

Dependent variable: in-hospital mortality. OR: odd ratio; CI: confidence interval; ISS: Injury Severity Score.

graphic extent of the Community of Madrid, which would allow the early arrival by terrestrial means to a hospital.

A ROSC was present in 13 of the 16 patients at hospital discharge. These results are more optimistic than those published by Margolin et al.[17] and similar to the German registry[8] with integrated medical presence in the EMS. In addition, short arrival times[7,20,21], added to an out-of-hospital activation of hospital trauma care teams[22], could have favourably influenced our results.

However, exsanguination continues to be one of the main causes of death in TCA and the first in our study, in which neither the volume administered nor the transfer times had statistical significance. The thoracotomy in ED was not associated with survival, with similar results to the literature[8,18]. For this reason, strategies for the control of haemorrhage of exsanguinate trauma continue to be integrated, some of which are now entrenched as permissive hypotension or protocols for massive bleeding[16]. Others are controversial, such as emergency thoracotomy[23]. Finally, there are also those in the study such as the Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA), cell preservation by means of hypothermia under support with extracorporeal circulation or Selective Aortic Arch Perfusion (SAAP)[24]. The impact of the integration of these measures together with the improvement in prehospital management and in the ED, where high percentages of errors were recorded according to Kleber et al.[25], could influence the prognosis of TCA.

Our results should be interpreted with caution since they present several limitations. On the one hand, its unicentric design and the disposition of a team specialized in the attention to the ST make that the results cannot be extrapolables to other locations or other emergency systems. The study design may have limited the statistical power of association of certain variables with in-hospital mortality. The low incidence has forced to compile information over a long period of time, 13 years, in which there have been changes in the recommendations of CPR as well as the management of ST. Finally, in our study, only the patients who were transferred to the hospital were analysed, so that the patients with TCA declared dead in the place were not included, which implies a possible selection of the patients by the EMSs, which, a priori, may have a higher probability of survival.

In conclusion, in our series TCA with on-site ROSC in-hospital survival of TCA was 12%, obtaining a favourable neurological recovery in eight out of ten patients alive. An initial rhythm in asystole in out-of-hospital care, on-hospital pupils on arrival at the hospital, and a score of > 25 on ISS were predictors of poor in-hospital prognosis.

Conflicting interests

The authors declare no conflict of interest reated to this article.

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Ethical Responsibilities

All authors have confirmed the maintenance of confidentiality and respect for patients' rights in the author's responsibilities document, publication agreement and assignment of rights to EMERGENCIAS.

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References

1 Rosemurgy AS, Norris PA, Olson SM, Hurst JM, Albrink MH. Prehospital traumatic cardiac arrest: the cost of futility. J Trauma. 1993;35:473-4.
2 Stockinger ZT, McSwain Jr NE. Additional evidence in support of withholding or terminating cardiopulmonary resuscitation for trauma patients in the field. J Am Coll Surg. 2004;198:227-31.
3 Mollberg NM, Wise SR, Berman K, Chowdhry S, Holevar M, Sullivan R, et al. The consequences of noncompliance with guidelines for withholding or terminating resuscitation in traumatic cardiac arrest patients. J Trauma. 2011;71:997-02.
4 Willis CD, Cameron PA, Bernard SA. Cardiopulmonary resuscitation after traumatic cardiac arrest is not always futile. Injury. 2006;37:448-54.
5 Deasy C, Bray J, Smith K, Harriss L, Morrison C, Bernard S, et al. Traumatic out of hospital cardiac arrests in Melbourne, Australia. Resuscitation. 2012;83:465-70.
6 Grasner JT, Wnent J, Seewald S, Meybohm P, Fischer M,. Paffrath T, et al. Cardiopulmonary resuscitation traumatic cardiac arrest: there are survivors. An analysis of two national emergency registries. Crit Care. 2011;15:R276.
7 Leis CC, Hernández CC, Blanco MJ, Paterna PC, Hernández RE, Torres EC. Traumatic cardiac arrest: should advanced life support be initiated? J Trauma. 2013;74:634-8.
8 Huber-Wagner S, Lefering R, Qvick LM, Korner M, Kay MV, Pfeifer KJ, et al. Outcome in 757 severely injured patients with traumatic cardiorespiratory arrest. Resuscitation. 2007;75:276-85.
9 Soar J, Perkins GD, Abbas G, Alfonzo A, Barelli A, Bierens JJ, et al. European Resuscitation Council Guidelines for Resuscitation 2010 Section 8. Cardiac arrest in special circumstances: Electrolyte abnormalities, poisoning, drowning, accidental hypothermia, hyperthermia, asthma, anaphylaxis, cardiac surgery, trauma, pregnancy, electrocution. Resuscitation. 2010;81:1400-33.
10 Truhlář A, Deakin CD, Soar J, Khalifa GE, Alfonzo A, Bierens JJ, et al, European Resuscitation Council Guidelines for Resuscitation 2015 Section 4. Cardiac arrest in special circumstances. Resuscitation. 2015;95:148-201.
11 Chico Fernández M, Llompart Pou JA, Guerrero López F, Sánchez Casado M, García Sáez I, Mayor García MD, et al. Epidemiology of severe trauma in Spain. Registry of trauma in the ICU (RETRAUCI). Pilot phase. Med Intensiva. 2016;40:327-47.

12 Grunau B, Reynolds JC, Scheuermeyer FX, Stenstrom R, Pennington S, Cheung C, et al. Comparing the prognosis of those with initial shockable and non-shockable rhythms with increasing durations of CPR: Informing minimum durations of resuscitation. Resuscitation. 2016;101:50-6.
13 Battistella FD, Nugent W, Owings JT, Anderson JT. Field triage of the pulseless trauma patient. Arch Surg. 1999;134:742-5.
14 Smith JE, Rickard A, Wise D. Traumatic cardiac arrest. J R Soc Med. 2015;108:11-6.
15 Rossaint R, Bouillon B, Cerny V, Coats TJ, Duranteau J, Fernández Mondéjar E, et al. The European guideline on management of major bleeding and coagulopathy following trauma: fourth edition. Crit Care. 2016;20:100.
16 Sanjeev B, Tej Prakash S, Prakash Ranjan M. Is it the time to integrate "sono cardiopulmonary resuscitation" in cardiopulmonary resuscitation algorithm of traumatic cardiac arrest? Indian J Crit Care Med. 2015;19:696-7.
17 Margolin DA, Johan DJ, Fallon WF. Response after out of hospital cardiac arrest in the trauma patient should determine aeromedical transport to a trauma center. J Trauma. 1996;41:721-5.
18 Pickens JJ, Copass MK, Bulger EM. Trauma patients receiving CPR: predictors of survival. J Trauma. 2005;58:951-8.
19 Evans CC Petersen A, Meier E.N, Buick J.E, Schreiber M, Kannas D, et al. Prehospital traumatic cardiac arrest: management and outcomes from the Resuscitation Outcomes Consortium Epistry-Trauma and PROPHET registries. J Trauma Acute Care Surg. 2016;85:285-93.
20 Shin SD, Kitamura T, Hwang SS, Kajino K, Song KJ, Ro YS, et al. Association between resuscitation time interval at the scene and neurological outcome after out-of-hospital cardiac arrest in two Asian cities. Resuscitation. 2014:85:203-10.
21 Soto-Araujo L, Costa-Parcero M, González-González MD, Sánchez-Santos L, Iglesias-Vázquez JA, Rodríguez-Núñez A. Factores pronóstico de supervivencia en la parada cardiaca extrahospitalaria atendida con desfibriladores externos semiautomáticos en Galicia. Emergencias. 2015;27:307-12.
22 Tiel Groenestege-Kreb D, van Maarseveen O, Leenen L. Trauma team. Br J Anaesth. 2015:113:258-65.
23 Harris T, Masud S, Lamond A, Abu-Habsa M. Traumatic cardiac arrest: a unique approach. Eur J Emerg Med. 2015;22:72-8.
24 Kutcher ME, Forsythe RM, Tisherman SA. Emergency preservation and resuscitation for cardiac arrest from trauma. Int J Surg. 2016;33:209-12.
25 Kleber C, Giesecke MT, Lindner T, Haas NP, Buschmann CT. Requirement for a structured algorithm in cardiac arrest following major trauma: epidemiology, management errors, and preventability of traumatic deaths in Berlin. Resuscitation. 2014;85:405-10.