REUE | Original Article

Factors related to the Emergency Medical Service initiation of vasoactive support in initially stable trauma patients

Fernando Monforte-Escobar, Alberto Hernández-Tejedor, Ervigio Corral Torres

BACKGROUND AND OBJECTIVE. First responders from emergency medical services have limited diagnostic capabilities in cases of severe trauma. The clinical status of some initially stable patients worsens significantly during care and transport. We aimed to identify factors associated with prehospital initiation of vasoactive support in initially stable patients with severe trauma.

MATERIAL AND METHODS. Retrospective observational case-control study in a single emergency service in a large urban area. Patients with severe trauma attended between 2018 and 2021 were included if they were hemodynamically stable at the start of care and were transferred to a hospital. Patients who received vasoactive support (cases) were compared to those who did not (controls). We studied differences in clinical variables, vital signs, and blood test results using multivariate analysis.

RESULTS. A total of 652 patients were enrolled. Thirty-seven received vasoactive support and 615 did not. Differences were found in the following variables: systolic blood pressure, mean arterial pressure, shock index, score on the Glasgow coma scale, pH, and PCO_2. Only 2 variables differed significantly on multivariate analysis. One was prehospital orotracheal intubation unrelated to cardiac arrest, with an adjusted odds ratio (aOR) of 7.51 (2.45-23.01); the other was reversed cardiac arrest witnessed by the advanced life support responders, with an aOR of 91.90 (16.08-525.09) (*P* < .001, both comparisons).

CONCLUSIONS. During early care for initially stable patients with severe trauma being transported to a hospital, the 2 variables associated with starting vasoactive support are prehospital orotracheal intubation unrelated to cardiac arrest and cardiac arrest reversed during attendance by an advanced life support ambulance.

Keywords: Emergency medical services. Potentially serious trauma. Vasoactive support.

Factores relacionados con el inicio prehospitalario de soporte vasoactivo en pacientes traumáticos inicialmente estables

INTRODUCTION. La capacidad diagnóstica de los servicios de emergencias (SEM) durante la atención inicial al trauma grave es limitada. Algunos pacientes que inicialmente se encuentran estables a la llegada del SEM, sufren posteriormente un deterioro clínico significativo durante la asistencia. El objetivo de este estudio fue determinar qué factores se relacionan con el inicio de soporte vasoactivo en el medio extrahospitalario, en pacientes traumáticos inicialmente estables.

MATERIAL Y MÉTODOS. Estudio unicéntrico, observacional, retrospectivo, de casos y controles, realizado en un SEM urbano de una gran ciudad. Fueron incluidos en el estudio los pacientes traumáticos graves atendidos de 2018 a 2021 que, al inicio de la asistencia, se encontraban hemodinámicamente estables y que fueron trasladados a un centro hospitalario. Se comparó a los pacientes que recibieron soporte vasoactivo (casos) *versus* aquellos que no lo recibieron (controles). Se estudiaron las diferencias entre variables clínicas, constantes vitales y parámetros analíticos sanguíneos. Posteriormente se ajustaron los resultados mediante un análisis multivariante.

RESULTADOS. Se incluyeron finalmente 652 pacientes. De ellos, 37 recibieron soporte vasoactivo y 615 no lo recibieron. El estudio mostró diferencias entre ambos grupos en la presión arterial sistólica, presión arterial media, índice de *shock*, puntuación en la escala de coma de Glasgow, pH y pCO_2. Las únicas variables que mantuvieron la significación estadística tras el ajuste multivariante fueron la intubación orotraqueal (IOT) extrahospitalaria no relacionada con parada cardiorrespiratoria (PCR), con una OR ajustada de 7,51 (2,45-23,01); y la PCR presenciada que ocurrió durante la atención por la unidad de soporte vital avanzado (USVA) y fue recuperada, con una OR ajustada de 91,90 (16,08-525,09). Ambas con p < 0,001.

CONCLUSIONES. Durante la atención inicial de pacientes traumáticos inicialmente estables que son trasladados a un centro hospitalario, la IOT extrahospitalaria no relacionada con PCR y la PCR acaecida durante la asistencia de una USVA y recuperada, son dos factores asociados de forma independiente con el inicio de soporte vasoactivo en medio extrahospitalario.

Palabras clave: Servicios de emergencias. Trauma potencialmente grave. Soporte vasoactivo.

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Introduction

Severe traumatic injury (STI) represents a major public health problem and is one of the leading causes of morbidity and mortality worldwide.[1,2] In Spain, statistics published by the National Institute of Statistics show that severe trauma is a frequent cause of death, with traffic accidents and workplace accidents being particularly notable.[3]

Out-of-hospital emergency medical services (EMS) are typically the first link in the health care chain in the management of STI in our setting. The timeliness and quality of their interventions have a direct impact on patient morbidity, mortality, and survival. Frequently, when EMS arrive at the scene, trauma patients are stable, without visible injuries or clinical signs suggestive of severity, and are therefore classified as potentially severe patients. Some of these patients have significant internal injuries that remain occult but will eventually lead to clinical deterioration either during out-of-hospital care or once at the receiving hospital after transfer. The absence of diagnostic tools capable of identifying internal injuries in the prehospital setting underscores the need to further analyze factors associated with clinical deterioration in initially stable patients.

The aim of this study is to identify possible variables associated with the administration of vasopressor support in the prehospital setting among trauma patients who are hemodynamically stable at the arrival of an advanced life support unit (ALS).

Materials and methods

We conducted a single-center, observational, retrospective case-control study in an urban EMS system serving a large city. From all patients attended for severe trauma between 2018 and 2021, only those who presented with initial hemodynamic stability—defined as systolic blood pressure (SBP) $\geq$ 90 mmHg and heart rate (HR) $\leq$ 120 bpm—and who were transported to a hospital were included. Patients who ultimately died in the prehospital setting or who were in cardiac arrest (CA) upon ALS arrival were excluded from the analysis. Patients who did not receive vasopressor support with norepinephrine during out-of-hospital care were included in the control group, and comparisons were drawn against those who did receive it (cases). The decision to initiate vasopressor support was made by the ALS physician responsible for patient care, following standard protocols. Study data were obtained from the EMS registry.

Inter-group differences were analyzed for the following variables: age, sex, prehospital orotracheal intubation (OTI), CA witnessed and recovered by ALS personnel, penetrating trauma, and volume of fluid administered. Vital signs were also compared: SBP, diastolic blood pressure (DBP), mean arterial pressure (MAP), HR, shock index (SI), respiratory rate (RR), and Glasgow Coma Scale (GCS) score. All values corresponded to the first measurement obtained by the ALS unit. In addition, differences in laboratory parameters were studied, obtained from a blood sample drawn during placement of the first venous access

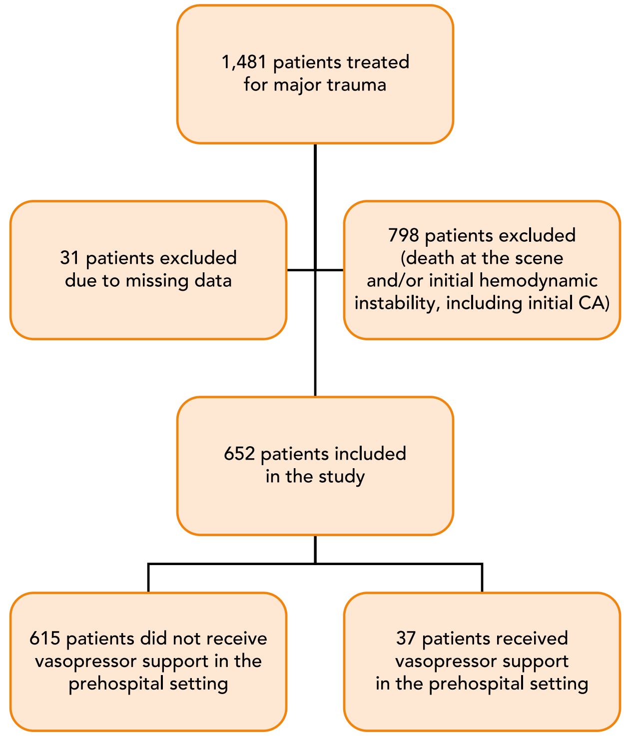

Figure 1. Patients included in the study
CA: cardiac arrest.

at the scene. This sampling was routinely performed in all severe trauma patients following EMS clinical procedures. Parameters included pH, partial pressure of CO_2 (pCO_2), base excess (BE), lactate, bicarbonate (HCO_3^-), anion gap (AGap), hemoglobin (Hb), hematocrit (Hct), glucose, creatinine, sodium (Na^+), chloride (Cl^-), potassium (K^+), and ionized calcium (Ca^{2+}). Blood samples were analyzed using a portable point-of-care device (EPOC®, Siemens Healthineers), part of the standard equipment for ALS units, capable of determining blood gas, biochemical, and hematimetric parameters.

For the univariate analysis, the GCS variable was divided into 3 subgroups (3–8, 9–12, 13–15); pH into 2 subgroups using a cutoff of 7.35; pCO_2 into 3 subgroups (< 35 mmHg, 35–45 mmHg, > 45 mmHg); base excess into 2 subgroups using a cutoff of –4 mmol/L; and lactate into 2 subgroups using a cutoff of 6 mmol/L. Normality of the quantitative variables was assessed using the Shapiro–Wilk test, which confirmed that the data did not follow a normal distribution. Median and interquartile range were calculated, and the Mann–Whitney U test, chi-square test, or Fisher's exact test were used to assess inter-group differences. Variables showing statistical significance in the univariate analysis were included in a multivariate analysis performed using logistic regression. Variables were entered using the enter method. Adjusted p values and adjusted odds ratios (ORs) with their corresponding 95% confidence intervals were obtained. Statistical significance was defined as a *P* value < .05. Statistical analysis was performed using SPSS, version 25. The study was approved by the SAMUR–Protección Civil Research Committee and was part of a broader project approved by the Clinical Research Ethics Committee (CEIm) of Hospital Clínico San Carlos (Madrid, Spain). The STROBE guidelines for observational epidemiologic studies were followed. The study received no funding.

Results

During the study period, a total of 1,481 patients with severe trauma were treated. Thirty-one patients were excluded due to missing key data in the medical records, and 798 patients were excluded because they were not hemodynamically stable upon arrival of the ALS unit, were in CA upon ALS arrival, or had been declared dead at the scene. The remaining 652 patients included in the analysis were divided into two groups according to whether they received vasopressor support with norepinephrine (37 patients) or did not receive it (615 patients) during prehospital care (Figure 1).

The main characteristics of each group are shown in Table 1. The median age of the sample was 39 years (IQR, 26–54), and 76.9% were male. Of the 652 patients included, 24 were aged 16 years or younger, and all belonged to the group that did not receive vasopressor support. The injury mechanisms are shown in Table 2. The most frequent mechanisms in the study population were motorcycle or moped collision (108), pedestrian strike (104), fall from height (104), ground-level fall (100), and stab wound (92). Table 3 shows response and care times. For the total sample, the median (IQR) response time was 8 min 22 s (6 min 23 s–11 min 2 s), on-scene time 32 min 30 s (26 min 27 s–41 min 14 s), and transport time 11 min 34 s (7 min 47 s–16 min 19 s).

In the univariate analysis (Tables 1, 3, and 4), 67.6% of patients who received vasopressor support during prehospital care were intubated (not related to CA) and put on mechanical ventilation vs 42.2% of those who did not receive vasopressors ($P = .03$). Differences were also found in CA occurring during ALS care and successfully resuscitated: 0.8% in the control group vs 18.9% in the vasopressor group ($P < .001$). Hemodynamically, patients who ultimately received vasopressor support had a lower initial systolic blood pressure (median 115 mmHg [95–133] vs 130 mmHg [110–143] in controls; $P = .005$), lower initial mean arterial pressure (84 mmHg [73–102] vs 93 mmHg [82–107]; $P = .031$), and a higher initial shock index (0.81 [0.61–0.95] vs 0.69 [0.55–0.83]; $P = .028$). In the vasopressor group, 40.5% of patients had an initial GCS of 3–8 vs 23.1% in the control group ($P = .016$). Conversely, 40.5% of patients in the vasopressor group had a GCS of 12–15 vs 64.2% in the control group ($P = .004$). Regarding blood gas results, only pH and pCO_2 were significant. An initial pH < 7.35 was present in 79.3% of patients who received vasopressors vs 49.7% of those who did not ($P = .015$). An initial pCO_2 > 45 mmHg was present in 62.2% of patients in the vasopressor group; in the group without vasopressors, the percentage was 37.3% ($P = .003$). No other variables showed differences.

In the multivariate analysis (Table 5), only prehospital OTI not related to CA (adjusted OR, 7.51 [95%CI, 2.45–23.01]) and CA occurring during ALS care (adjusted OR, 91.90 [95% CI, 16.08–525.09]) remained significant, both with $P < .001$.

Table 1. Univariate analysis of the characteristics of patients included in the study in each group. Median and interquartile range. Frequency and percentage, with percentage calculated relative to the classification group

	No Vasopressor Support	Vasopressor Support	OR (95% CI)	*P*-value
Sex			1.9 (0.95-3.97)	.066
Male	493 (80.2%)	25 (67.6%)		
Female	122 (19.8%)	12 (32.4%)		
Age (years)	39 (26-54)	47 (30-65)		.061
Out-of-hospital OTI not related to CA	261 (42.4%)	25 (67.6%)	2.8 (1.39-5.73)	.003
CA occurring during ALS care and resuscitated	5 (0.8%)	7 (18.9%)	28.47 (8.53-94.62)	< .001
Approximate total volume administered (mL)	500 (300-800)	450 (200-875)		.461
Penetrating trauma	89 (14.5%)	3 (8.1%)	0.521 (0.52-1.73)	.280

OTI: orotracheal intubation; CA: cardiac arrest; ALS: advanced life support unit.

Table 2. Injury mechanisms. Frequency and percentage relative to each group. Patients with thermal burns and with smoke inhalation syndrome (SIS) were included in one of the two groups according to the severity of their injuries

	Total	No vasopressor support	Vasopressor support
Motorcycle/moped accident	108 (16.6%)	101 (16.4%)	7 (18.9%)
Pedestrian struck	104 (16%)	97 (15.8%)	7 (18.9%)
Fall from height	104 (16%)	94 (15.3%)	10 (27%)
Same-level fall	100 (15.3%)	99 (16.1%)	1 (2.7%)
Stab wound	92 (14.1%)	89 (14.5%)	3 (8.1%)
Traffic accident	41 (6.3%)	39 (6.3%)	2 (5.4%)
Bicycle accident	22 (3.4%)	22 (3.6%)	0 (0%)
Thermal burns	18 (2.8%)	17 (2.8%)	1 (2.7%)
Run over/crush	16 (2.5%)	14 (2.3%)	2 (5.4%)
Blunt object trauma	12 (1.8%)	11 (1.8%)	1 (2.7%)
SIS	10 (1.5%)	9 (1.5%)	1 (2.7%)
E-scooter/PMV accident	9 (1.4%)	8 (1.3%)	1 (2.7%)
Firearm injury	6 (0.9%)	0 (0%)	6 (1%)
Electrocution	4 (0.6%)	4 (0.7%)	0 (0%)
Hanging	4 (0.6%)	3 (0.5%)	1 (2.7%)
Entrapment	2 (0.3%)	2 (0.3%)	0 (0%)

SIS: smoke inhalation syndrome; PMV: personal mobility vehicle.

Table 3. Response and assistance times (in minutes and seconds) of the ALS unit. Median and interquartile range

	No vasopressor support	Vasopressor support	*P*-value
ALS response time			
Activation and arriva	8 min 29 s (6 min 25 s-11 min 7 s)	7 min 31 s (5 min 50 s-9 min 30 s)	.152
ALS assistance time			
On-site assistance	32 min 30 s (26 min 21 s-41 min 19 s)	32 min 44 s (27 min 43 s-39 min 34 s)	.867
Transport time	11 min 4 s (7 min 48 s-16 min 21 s)	7 min 53 s (7 min 37 s-15 min 9 s)	.309

ALS: advanced life support unit.

Table 4. Univariate analysis of clinical and laboratory variables. Median and interquartile range. Frequency and percentage within each classification group

	No vasopressor support	Vasopressor support	OR (95% CI)	*P*-value
Initial HR (bpm)	90 (78-104)	92 (75-108)		.655
Initial SBP (mmHg)	130 (110-143)	115 (95-133)		**.005**
Initial DBP (mmHg)	80 (69-90)	70 (63-90)		.082
Initial MAP (mmHg)	93 (82-107)	84 (73-102)		**.031**
Initial SI	0.69 (0.55-0.83)	0.81 (0.61-0.95)		**.028**
Initial RR (rpm)	16 (14-20)	15 (12-18)		.094
Initial GCS (points)				
12–15	395 (64.2%)	15 (40.5%)	**0.38 (0.19-0.75)**	**.004**
9–11	78 (12.7%)	7 (18.9%)	1.61 (0.68-3.78)	.274
3–8	142 (23.1%)	15 (40.5%)	**2.27 (1.14-4.94)**	**.016**
pH	7.35 (7.29-7.39)	7.28 (7.17-7.35)		**< .001**
pH < 7.35	291 (49.7%)	26 (79.3%)	**2.39 (1.16-4.92)**	**.015**
pCO_2 (mmHg)	42.2 (35.8-49.10)	47 (42.05-58.85)		**.001**
< 35	123 (21.2%)	3 (8.1%)	0.33 0.10-1.08)	.059
35–45	238 (41.1%)	11 (29.7%)	0.60 (0.29-1.25)	.172
> 45	218 (37.3%)	23 (62.2%)	**2.72 (1.37-5.40)**	**.003**
HCO_3^- (mmol/L)	23.3 (20.7-25.6)	23.3 (20.5-25.5)		.759
Lactate (mmol/L)	3.63 (2.58-5.78)	4.58 (2.87-7.12)		.125
≥ ±	134 (23.1%)	11 (29.7%)	1.41 (0.68-2.93)	.350
BE (mmol/L)	–2.1 (–5–-0.3)	–2.2 (–5.75–-0.45)		.877
< –4	172 (29.7%)	12 (32.4%)	1.17 (0.56-2.31)	.730
Anion gap (mmol/L)	15 (13-18)	16 (12-18)		.987
Hemoglobin (g/dL)	15.5 (14.2-16.5)	15.2 (14-16.6)		.580
Hematocrit (%)	46 (42-49)	44 (41-48)		.312
Glucose (mg/dL)	134 (115-161)	139 (114-183)		.408
Na^+ (mmol/L)	142 (140-143)	142 (139.50-144)		.492
Cl^- (mmol/L)	107 (105-109)	108 (105.75-110.25)		.090
K^+ (mmol/L)	3.7 (3.4-4)	3.8 (3.4-4.4)		.101
Ionized Ca^{2+} (mmol/L)	113 (108-119)	112 (110-119.5)		.980
Creatinine (mg/dL)	1.05 (0.86-1.26)	1.13 (0.95-1.38)		.090

HR: heart rate; SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; RR: respiratory rate; GCS: Glasgow Coma Scale; pCO_2: partial pressure of CO_2; HCO_3^-: bicarbonate; BE: base excess; AGap: anion gap; Hb: hemoglobin; Hct: hematocrit; OR: odds ratio; SI: shock index.

Table 5. Multivariate analysis of variables statistically significant in the univariate analysis. Adjusted *P*-value and adjusted odds ratio

	Adjusted OR (95% CI)	*P*-value
Out-of-hospital intubation not related to cardiac arrest	7.51 (2.45-23.01)	< .001
CA occurring during care from ALS unit and recovered	91.90 (16.08-525.09)	< .001
Initial SBP	0.96 (0.92-1.01)	.074
Initial MAP	1.03 (0.98-1.08)	.221
SI	2.48 (0.26-23.97)	.434
GCS (points)		
13–15	0.90 (0.23-2.69)	.845
3–8	0.84 (0.29-2.42)	.748
pH		
< 7.35	1.50 (0.55-4.09)	.428
pCO_2 (mmHg)		
> 45	1.37 (0.52-3.57)	.524

OTI: orotracheal intubation; CA: cardiac arrest; ALS: advanced life support unit; SBP: systolic blood pressure; MAP: mean arterial pressure; GCS: Glasgow Coma Scale; pCO_2: partial pressure of CO_2; SI: shock index.

Discussion

In our study, out-of-hospital OTI not associated with CA and CA occurring during ALS care and successfully resuscitated were the only variables independently associated with the initiation of vasopressor support in initially stable trauma patients transported to a hospital.

The age and sex distribution of the study population are similar to existing severe trauma registries[1,2,4]. Although sex differences were not statistically significant, a greater proportion of women received vasopressor support. Former studies have explored sex-related differences in trauma severity and outcomes, with some describing higher morbidity and mortality in women[5,6].

There is no universally accepted definition of hemodynamic instability, as the concept includes multiple physiopathological implications. Definitions often incorporate macrohemodynamic parameters, microcirculatory variables, the need for therapeutic intervention, and the patient's response to that intervention. For this study, hemodynamic stability was defined as SBP ≥ 90 mmHg and HR ≤ 120 bpm.

Traditionally, vital signs such as HR, RR, and SBP have been used as indicators of hemorrhagic shock severity[8] due to their ease of measurement. However, in the prehospital setting, macrohemodynamic variables must be interpreted cautiously, as the initial sympathetic response due to injury, emotional stress, or pain may mask the true hemodynamic state.[8-12] In our study, the univariate analysis showed significant differences in initial SBP (*P* = .005), initial MEAP (*P* = .031), and initial SI (*P* = .028), although these differences lost significance in the multivariate analysis."

Various studies have demonstrated that certain blood analytical parameters become altered earlier than traditional macrohemodynamic parameters and have prognostic value in patients with severe trauma. Several studies have shown the usefulness of base excess (BE) and lactate as in-hospital biomarkers in severe trauma, as both are associated with hemorrhage severity, transfusion requirements, occult hypoperfusion, patient prognosis, and morbidity and mortality.[9-12] Although available evidence on prehospital biomarkers is far more limited, a recent study involving our EMS system also found a statistically significant and clinically relevant association between pH and pCO_2 and patient severity measured by the New Injury Severity Score (NISS).[17] Given the limitations of interpreting traditional vital signs during the initial management of severe trauma, further research on these prognostic biomarkers is needed.

Despite the well-established usefulness of analytical parameters in severe trauma care, our study did not identify independent analytical predictors associated with the initiation of vasopressor support in the prehospital setting in trauma patients with initial hemodynamic stability. In the univariate analysis, both pH and pCO_2 showed statistically significant differences between groups; however, these variables lost significance in the multivariate analysis. Although the analytical parameters in our study were obtained from venous samples and published literature generally refers to arterial samples, ample evidence supports the validity of lactate and BE as biomarkers in severe trauma regardless of sample origin.[18]

From a clinical perspective, the differences observed between groups in the number of patients with EMS-witnessed cardiac arrest who achieved return of spontaneous circulation—confirmed in the multivariate analysis (adjusted $P < .001$)—are logical and expected. During early post-resuscitation care in traumatic cardiac arrest, patients often present with marked hemodynamic instability that necessitates vasopressor support. Although identifying potential predictors of CA in initially stable trauma patients would be clinically valuable, our study included only 12 such patients who subsequently sustained CA during EMS care and were successfully resuscitated with advanced life support. This small subgroup limits statistical power and the ability to draw robust conclusions.

Differences between groups regarding prehospital OTI not related to cardiac arrest were also confirmed in the multivariate analysis (adjusted $P < .001$). Former studies have demonstrated the hemodynamic impact of mechanical ventilation (MV).[19] Post-intubation hemodynamic instability is associated with decreased vascular tone due to sedative–paralytic agents and reduced venous return secondary to increased intrathoracic pressure.[20] Typically, sympathetic activation and the renin–angiotensin system mitigate the deleterious effects of intubation and MV; however, these compensatory mechanisms are impaired in hypovolemia, acidosis, and hypercapnia,[21] common in severe trauma. Based on our results, further research is needed to identify predictors of hemodynamic instability after prehospital OTI during early trauma care. In clinical practice, pCO_2 and GCS scores are closely related to the need for OTI. The strong association between OTI and vasopressor administration—adjusted OR 7.51 (2.45–23.01)—likely explains why pCO_2 and GCS initially showed statistically significant differences in the univariate analysis but lost significance in the multivariate model.

Among the main strengths of our study are its focus on the prehospital phase of care, the high number of prospectively collected cases, and the novel evidence provided in an area with limited existing prehospital research.

Nevertheless, interpretation of results should consider the imbalance in group sizes. Of the 652 severe trauma patients attended by EMS with initial hemodynamic stability and subsequently transported to a hospital, only 37 (0.56%) received prehospital vasopressor support. This figure should be interpreted within the context of an urban EMS system with short response and transport times. Longer response, on-scene, and transport times could provide a wider time window during which patients may deteriorate and require vasopressors. Patients who were initially stable upon the arrival of the ALS unit but ultimately died were not included. Although this number is likely small, given the observed association between CA and vasopressor administration, it is probable that some of these patients received vasopressors. Finally, the activation of the ALS unit sometimes occurs after an initial assessment by a basic life support unit. In such cases, a longer time elapses between the incident and the care provided by the advanced ALS unit, and thus vital signs, clinical variables, and analytical parameters may no longer reflect very early physiologic changes.

Conclusions

Prehospital OTI not related to CA and CA occurring during EMS care with subsequent resuscitation were independently associated with initiation of vasopressor support during prehospital management of initially hemodynamically stable trauma patients transported to a hospital.

Given the clinical relevance of these findings, further investigation into the hemodynamic status of trauma patients at the time of intubation and into potential predictors of post-intubation hemodynamic instability in the prehospital setting is warranted."

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