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# The importance of pre-trauma centre treatment of life-threatening events on the mortality of patients transferred with severe trauma☆

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ABSTRACT

*Aim:* The benefit of a well organised trauma system is acknowledged but doubts remain concerning the optimal pre-hospital trauma care model. We hypothesise that the treatment of life-threatening events before arrival at trauma centre – either pre-hospital or first hospital – may be more relevant to decreasing mortality than shortening the time to trauma centre.
*Methods:* A cohort of 727 trauma patients with life-threatening events – identified as airway, breathing, circulation or neurological disability – requiring transfer to a trauma centre were studied. Data on patient's characteristics, trauma features, and mortality were taken from a trauma registry. Patients were divided into 3 groups depending on the place of treatment of life-threatening events: pre-hospital, first hospital or trauma centre. Survival Kaplan–Meier curves and logistic regression were used to assess the effect of place of treatment of life-threatening events on mortality.
*Results:* Patients from the pre-hospital and first hospital groups had 20% and 27% mortality respectively, compared to 38% among those whose life-threatening events were corrected only at the trauma centre. Logistic regression showed that patients whose life-threatening events were corrected only at the trauma centre had an odds of death 3.3 times greater than those from the pre-hospital group, adjusted for patient and trauma characteristics and time to trauma centre.
*Conclusion:* In trauma patients requiring transfer to a trauma centre, pre-hospital interventions to treat life-threatening events may significantly decrease mortality when compared to similar interventions performed later at the trauma centre.



## 1. Introduction

The benefit of a well organised trauma system with specialized trauma centres is fully acknowledged,[1–4] but doubts still remain concerning what could be considered as the optimal pre-hospital trauma care. Several authors have studied the effect of pre-hospital *advanced* life support (ALS) in comparison with pre-hospital *basic* life support (BLS) approaches on trauma mortality and other outcomes.[5–9] However, there are no large or controlled studies on that subject and the controversy is far from being resolved. Even studies that address the effect of specialized trauma teams and helicopters on trauma patients' outcome showed conflicting results.[10–12]

Moreover, studies that compare pre-hospital ALS and BLS approaches often have different definitions for ALS and BLS, study only partial ALS attitudes or techniques – instead of the whole concept – and above all do not study and compare ALS and BLS in a population of trauma patients with life-threatening events needing treatment.[13]

Traumatic life-threatening events were defined in the medical literature as events that endanger life and that should be corrected during the primary survey of treatment of trauma patients. By definition life-threatening events should be treated urgently. The methodology to identify and treat life-threatening events is also known as ABCD methodology and is taught in different trauma courses around the world namely European Trauma Course[14] and ATLS.[15]

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Our aim was to estimate the effect on mortality of treating the life-threatening events prior to arrival at the trauma centre (either in the pre-hospital scene or in the first hospital) in comparison with treatment of life-threatening events only at the trauma centre. We considered two hypotheses: (1) The early treatment of life-threatening events in trauma patients decreases the risk of death. (2) Time from accident to definitive treatment at trauma centre is an independent factor contributing to mortality.

## 2. Methods

### 2.1. Setting

We analysed data from a trauma registry that includes all patients admitted to a neurosurgical centre in the North of Portugal (Hospital de Santo António—HGSA). HGSA is a 700 bedded University acute central hospital with neurosurgical cover and intensive care facilities. No other hospital within this trauma system has emergency neurosurgical coverage. HGSA serves Northeast Portugal (a mixed urban/rural area) with a catchment area of approximately 2,500,000 inhabitants. The Emergency Medical System (EMS) within this region consists of a dispatch centre that answers all emergency calls (112) and sends the most appropriate resource available. One helicopter and 10 fast vehicles with trained medical doctors are available for this response.[16] The decision whether or not to dispatch a physician to the field is reached on the basis of the information received on the phone and the available resources. As the resources are not uniform for the same severity of trauma, different approaches are possible from an ALS vehicle with doctor and nurse to an BLS Ambulance staffed only by fire-fighters with basic skills. If an ALS resource is not available BLS ambulances attend the scene and transport the patient to the nearest hospital with an emergency department (ED). Such ALS teams with medical involvement are only available in urban areas. As a consequence the level of trauma care in the designated area is not uniform. In Portugal the trauma centre levels, according to the American College of Surgeons,[17] are not used for accreditation; most first hospitals with ED are comparable to level III trauma centres and if a neurosurgical and/or intensive care is needed the patient is transferred to HGSA, the level I trauma centre for this region.

### 2.2. Study design, patients and definitions

A trauma registry at HGSA has been prospectively maintained using Trauma Injury Severity Score methodology (TRISS) for severity coding.[18] For the purpose of this study we analysed data between August 2001 and December 2006. In addition the following information was collected after retrospective review of the patient's clinical notes: type of life-threatening event; type of life-threatening event treatment and location where the treatment was performed (pre-hospital, first hospital or trauma centre).

#### 2.2.1. Patients

We included in this study all trauma patients admitted to the emergency room of HGSA that were transferred from another hospital in the trauma system, corresponding to 72% of the severe trauma patients admitted to this trauma centre.

#### 2.2.2. Life-threatening events

Life-threatening events were defined as problems in the airway (A), breathing (B), circulation (C) or neurological disability (D) that may endanger life if not immediately identified and controlled as taught in trauma courses. The airway breathing circulation disability approach (ABCD approach) is a method of identifying and treating life-threatening events in trauma patients. It is taught in different trauma courses and emergency medicine courses for doctors, nurses and paramedics around the world.[14,15,19] At the end of the primary survey patients should have a patent airway, have oxygen on and have the cervical spine immobilized. Adequate ventilation must be confirmed afterwards. This includes an examination of the chest to clinically exclude or treat immediately life-threatening thoracic conditions. Tension pneumothorax, open chest wound, massive haemothorax, flail chest or cardiac tamponade are the thoracic life-threatening events. Regarding circulation any overt bleeding must be controlled by direct pressure. If a life-threatening event is identified in circulation (clinical evidence of shock using skin colour, clamminess, capillary refill time, heart rate, blood pressure, pulse pressure, conscious level and respiratory rate) intravenous access must be established and fluids started. Examinations should identify the origin of the problem but (apart from the external haemorrhage that should be controlled using direct pressure) usually that is only possible at hospital. Dysfunction of the central nervous system can be a life-threatening event. In our trauma system patients with D problems must be transferred to the trauma centre, and if the Glasgow coma scale of the patient is bellow 8, control of the airway is mandatory. When several life-threatening events were identified in the same patient, we considered the first one in alphabetic order to be treated, as defined by medical educational principles.

To avoid retrospective case definitions of head and severe injury as opposed to what the pre-hospital personnel identifies at the scene (paramedics or physicians at scene will not always know whether or not the unconscious trauma patient has a head trauma or degree of severity) we studied only patients with a life-threatening event identified (regardless of subsequent injury diagnoses).

Patients were divided into 3 groups related to the place of treatment of life-threatening events: pre-hospital, first hospital or trauma centre. Life-threatening events and treatments are described in Table 1.

#### 2.2.3. Time to trauma centre

Time to trauma centre was defined as time from the accident occurrence to the arrival at the level I trauma centre (HGSA).

The primary outcome measure used was trauma centre mortality. The descriptive analysis was made using appropriate summary tests. Categorical variables were described using absolute and relative (%) frequencies, continuous variables were analysed using mean as central tendency and standard deviation as a dispersion measurement and non-continuous variables using median as central tendency and inter-quartile range (IQR) as a dispersion measurement. When appropriate Chi-Square testing and Fisher's exact testing were applied to test hypothesis related to categorical variables. Survival Kaplan–Meier curves were done for patients in the 3 groups (pre-hospital, first hospital and trauma centre treatment of life-threatening events). Test of equality of survival distributions were done using Cox regression. To assess the predictive effect of the place of treatment of life-threatening events on mortality, several logistic regression models were constructed, with mortality as dependent variable and population characteristics as independent variables. Models were built using different independent variables from previous well know prognostic trauma models.[18,20,21] Statistical significance was set at the 0.05 level. SPSS®15.0 was used for statistical analysis.

## 3. Results

### 3.1. Population characteristics

Between 1st January 2001 and 31st December 2006, 1050 trauma patients were admitted to the emergency room of HGSA

**Table 1**
Patients' variables according to mortality and place of treatment of life-threatening events.

| | Total ($n$ = 727) | Case fatality | | $p$[a] | Life-threatening events treatment | | | $p$[a] |
|---|---|---|---|---|---|---|---|---|
| | | Alive ($n$ = 523) | Dead ($n$ = 204) | | Pre-hospital ($n$ = 49) | First hospital ($n$ = 580) | Trauma centre ($n$ = 98) | |
| Gender, $n$ (%) | | | | | | | | |
| Female | 157 (22) | 99 (19) | 58 (28) | 0.005 | 11 (22) | 123 (21) | 23 (24) | 0.871 |
| Male | 570 (78) | 424 (81) | 146 (72) | | 38 (78) | 457 (79) | 75 (77) | |
| Age, mean (*SD*) | 44 (21) | 42 (21) | 48 (21) | <0.001[b] | 38 (19) | 44 (21) | 48 (22) | 0.028[b] |
| Type of trauma $n$ (%) | | | | | | | | |
| Blunt | 690 (95) | 505 (97) | 185 (91) | 0.001 | 48 (98) | 546 (94) | 96 (98) | – |
| Penetrating | 37 (5) | 18 (3) | 19 (9) | | 1 (3) | 34 (6) | 2 (2) | |
| Mechanism of injury $n$ (%) | | | | | | | | |
| Road traffic collision | 422 (58) | 331 (63) | 91 (44) | – | 35 (71) | 331 (57) | 56 (57) | – |
| Fall | 217 (30) | 141 (27) | 76 (37) | | 8 (6) | 177 (31) | 32 (33) | |
| Assault, blunt | 5 (1) | 4 (1) | 1 (1) | | 0 (0) | 5 (1) | 0 (0) | |
| Other, blunt | 49 (7) | 32 (6) | 17 (8) | | 5 (10) | 36 (6) | 8 (8) | |
| Stabbing | 2 (0) | 2 (0) | 0 (0) | | 0 (0) | 2 (0) | 0 (0) | |
| Gunshot | 32 (4) | 13 (3) | 19 (9) | | 1 (2) | 29 (5) | 2 (2) | |
| AIS, *mean* (*SD*) | | | | | | | | |
| Head | 4.1 (0.9) | 4.0 (0.9) | 4.7 (0.7) | <0.001[b] | 4.2 (0.9) | 4.2 (0.9) | 4.0 (1.1) | 0.118[b] |
| Face | 1.9 (0.7) | 1.9 (0.7) | 1.8 (0.6) | 0.324[b] | 2.2 (0.8) | 1.8 (0.6) | 2.0 (0.8) | 0.148[b] |
| Thorax | 3.3 (1.0) | 3.3 (1.0) | 3.5 (1.0) | 0.058[b] | 3.0 (1.1) | 3.3 (1.0) | 3.7 (0.9) | 0.005[b] |
| Abdomen | 2.7 (1.1) | 2.6 (1.1) | 2.8 (1.2) | 0.536[b] | 2.4 (0.5) | 2.5 (1.1) | 2.9 (1.7) | 0.155[b] |
| Extremities | 2.2 (0.9) | 2.3 (0.9) | 2.2 (0.8) | 0.673[b] | 2.0 (0.7) | 2.2 (0.8) | 2.6 (1.0) | <0.001[b] |
| ISS, median (IQR) | 25 (18–32) | 25 (17–30) | 25 (25–34) | <0.001[c] | 22 (16–32) | 25 (18–29) | 29 (24–38) | 0.001[d] |
| RTS, median (IQR) | 5.9 (5–6.9) | 5.9 (5–6.9) | 5.0 (4–5.9) | <0.001[c] | 5.9 (4–6.9) | 5.9 (5–6.9) | 5.9 (5–7.1) | 0.238[d] |
| Probability of survival, *mean* (*SD*) | 0.69 (0.28) | 0.75 (0.25) | 0.54 (0.29) | <0.001[b] | 0.71 (0.31) | 0.70 (0.27) | 0.6 (0.32) | 0.011 |
| Outcome $n$ (%) | | | | | | | | |
| Died | 204 (28) | – | – | | 10 (20) | 157 (27) | 37 (38) | 0.044 |
| Discharged | 523 (72) | – | – | | 39 (80) | 423 (73) | 61 (62) | |
| Life-threatening events | | | | | | | | |
| A | 30 (4) | 25 (5) | 5 (3) | 0.479 | 0 (0) | 12 (2) | 4 (6) | – |
| B | 66 (9) | 49 (9) | 17 (8) | | 2 (6) | 37 (7) | 12 (16) | |
| C | 64 (9) | 47 (9) | 17 (8) | | 3 (8) | 13 (3) | 22 (30) | |
| D | 567 (78) | 402 (77) | 165 (81) | | 31 (86) | 426 (88) | 35 (48) | |

[a] Qui-Square test.
[b] Independent sample test.
[c] Mann–Whitney.
[d] Kuskall–Wallis; IQR: inter-quartile range.

and enrolled in the prospective registry. We included in this study 761 trauma patients transferred from another hospital. Twenty-five patients who had no life-threatening events identified were excluded from subsequent analyses. We also excluded 8 patients with missing data related to the presence or the treatment of life-threatening events.

Patients included had a mean age of 44 years (*SD* = 21). The majority were male (78%; *n* = 570) and had sustained injury through blunt trauma (95%; *n* = 690) with traumatic brain injury (TBI) in 87% of cases. The context of injury was road traffic collision (RTC) in 58% of cases (*n* = 422). All patients had severe trauma with a mean Abbreviated Injury Score (AIS) in the head of 4.1, a median Injury Severity Score (ISS) of 25 (IQR 18–32) and a median Revised Trauma Score (RTS) of 5.97 (IQR 5–6.9). The probability of survival (TRISS) for these patients was 69% and the real survival rate was 72% (Table 1).

### 3.2. Life-threatening events

In accordance with the ABCD assessment and treatment methodology, life-threatening events were identified. Not surprisingly most of the patients in this population had "D" problems (*n* = 567; 78%). We assumed that treatment for "D" problems was maintaining an adequate airway (including tracheal intubation if the GCS was less than 8 points) and aiming for good oxygenation and perfusion followed with early reference to a neurosurgical centre. For example: if a patient arrived at the first hospital with a possible head injury identified, a GCS less than 8 identified and the protection of the airway was performed in first hospital prior to transfer, then that patient was assumed to be part of the first hospital group (life-threatening event corrected in first hospital). If the identification and treatment of D problem was performed in pre-hospital before arrival at the first hospital then that patient was part of the pre-hospital group (life-threatening event corrected in the pre-hospital scene). If the same patient arrived at the trauma centre without intubation (and the need was present before arrival) then that patient would be part of the trauma centre group. The second most common life-threatening event involved breathing (*n* = 66; 9%) and it was corrected using a chest drain in 33 cases and mechanical ventilation in 31 patients. The same methodology described above was used to decide in which group each patient would be. Circulation life-threatening events were identified in 64 patients (9%) and fluids (6), vasopressors (6) and surgery (52) were the treatments performed. Airway life-threatening events were identified in 30 patients (4%) and were treated using oxygen (15) intubation (5), a cervical collar (7) and oxygen with basic airway manoeuvres (3). Cervical spinal cord injuries were included in the airway life-threatening events as airway assessment and treatment includes cervical spine control. It was assumed that all patients should have had a cervical collar, so if they had a spinal cord injury and no collar that was classified as a life-threatening event not corrected.

Whenever it was not possible to understand retrospectively if the life-threatening event was present before arrival at the first hospital or trauma centre or if it developed only during transportation to the trauma centre, that patient was excluded because of missing data. Table 2 lists life-threatening events and treatment and Table 1 shows mortality for different life-threatening events.

### 3.3. Place of treatment of life-threatening events and outcome

Most of the patients had their life-threatening events treated in pre-hospital or first hospital (pre-trauma centre) (*n* = 629; 87%). Life-threatening events were corrected in the pre-hospital environment in 49 patients (7%), in the first hospital in 580 (80%) and solely in trauma centre in 98 (13%) patients. Demographic and injury severity characteristics (Table 1) of these 3 groups of patients were similar except for age and ISS (patients who had life-threatening events treated in the pre-hospital phase were younger and less severely injured). Mortality rates differed across these 3 groups, 20% for patients with life-threatening events treated in the pre-hospital environment, 27% for those with events treated in first hospital and 38% for patients with life-threatening events solved only in the trauma centre (*p* = 0.044).

Fig. 1 shows the survival curves for the 3 groups of patients. Patients were more likely to survive when their life-threatening events were corrected in the pre-hospital phase, corresponding to a mortality reduction of almost 50% when compared to those patients whose life-threatening events were corrected later in trauma centre.

**Table 2**
Life-threatening events and treatments.

| Life-threatening events | |
|---|---|
| Airway (A) problem | 30 (4) |
| Airway obstruction | 23 (77) |
| Cervical spine injury | 7 (23) |
| Treatment | |
| Oxygen and Basic airway manoeuvres | 18 (60) |
| Tracheal intubation | 5 (16) |
| Cervical collar | 7 (24) |
| Breathing (B) problem | 66 (9) |
| Pulmonary contusion | 24 (37) |
| Massive Haemothorax | 17 (25) |
| Tension Pneumothorax | 16 (25) |
| Flail chest | 9 (13) |
| Treatment | |
| Oxygen | 66 (100) |
| Ventilation | 31 (47) |
| Chest drain | 33 (49) |
| Circulation (C) problem | 64 (9) |
| Clinical signs of shock | 64 (100) |
| Treatment | |
| Surgery | 52 (81) |
| Fluids | 6 (8) |
| Fluids + Vasoconstrictors | 6 (8) |
| Disability (D) problem | 567 (78) |
| GCS < 9 | 377 (66%) |
| GCS > 8 | 190 (34%) |
| Treatment | |
| Tracheal intubation | 377 (66%) |
| Referral to Neurosurgery | 567 (100) |

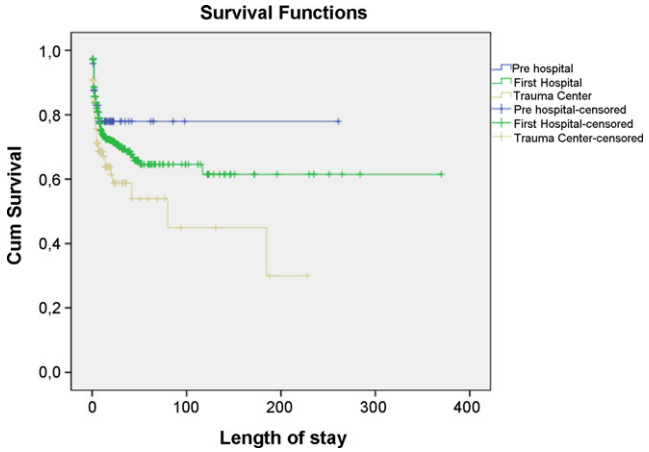


**Fig. 1.** Survival curves for patients with life-threatening events treated in pre-hospital, first hospital or trauma centre. Length of stay is depicted in days.

**Table 3**
Regression analysis for mortality.

| | OR | CI 95% | *p* |
|---|---|---|---|
| Gender | | | |
| Female | 1.000 | – | |
| Male | 0.549 | 0.361–.837 | 0.005 |
| Age | 1.015 | 1.006–1.024 | 0.001 |
| ISS | 1.044 | 1.025–1.063 | <0.001 |
| Type of trauma | | | |
| Penetrating | 1.000 | – | |
| Blunt | 0.193 | 0.087–0.429 | <0.001 |
| Place of treatment of life-threatening events | | | |
| Pre-Hospital | 1.000 | – | |
| First Hospital | 1.457 | 0.656–3.233 | 0.355 |
| Trauma Centre | 3.256 | 1.276–8.309 | 0.014 |
| RTS | 0.617 | 0.535–0.713 | <0.001 |
| Time to trauma centre | 1.000 | 0.999–1.001 | 0.568 |
| C Statistic | 0.757 | | |

Variables in the model: gender, age, ISS, RTS, type of trauma, place of treatment of life-threatening events and time to trauma centre. Enter method was used.

Time from accident to trauma centre (including pre-hospital and first hospital times) was also compared. Patients with life-threatening events solved in pre-hospital, first hospital and trauma centre phases had respectively a median time from accident to trauma centre of 5 h and 31 min (IQR 3:45–9:24), 4 h and 35 min (IQR 2:50–7:02), and 3 h and 30 min (IQR 2:51–6:56).

As the univariate analyses showed that patients whose life-threatening events where treated in the pre-hospital environment had lower mortality but at the same time were younger and less severely injured, a multivariate logistic regression was performed to adjust the odds of death to patient characteristics and trauma severity as well as time from accident to trauma centre. Logistic regression showed that increases in mortality were associated with female gender and older age, penetrating type of trauma, higher anatomic severity (ISS), higher physiological severity (RTS) and having the life-threatening events corrected only at the trauma centre (Table 3). Different models using TRISS and other severity model variables and categories were constructed but did not show a better performance in this population and are not shown.

## 4. Discussion

Our main finding was that the treatment of life-threatening events in the pre-hospital scene (compared to the treatment of life-threatening events only at first hospital or the trauma centre) decreased the mortality of severe trauma patients transferred to a trauma centre. A reduction of almost 50% in crude mortality was found for those patients having their life-threatening events treated in the pre-hospital phase. This observed benefit was maintained after adjustment for confounders in logistic regression analysis. As a result we believe that in the context of this report pre-hospital ALS and the ability to treat life-threatening events had a positive effect on mortality reduction. We accepted our first hypothesis.

In the literature not many studies support a positive relationship of ALS with outcome but most are able to show an increase of on-scene time when ALS is performed. Several important reviews summarise well the results of relevant studies. Liberman in a meta-analysis reviews and critiques the literature on ALS and BLS influence on outcome. He reviews 174 papers, recovers only 15 that permit an outcome analysis, was unable to find any large randomised prospective study, and concludes that "...the aggregated data from the literature have failed to demonstrate a clear benefit from on-site ALS in trauma".[10] Bunn et al. in a review supported by the World Health Organisation identifies only one small randomised study that is in favour of the ALS and concludes on the absence of evidence of the effectiveness of ALS in the pre-hospital setting.[12] However, different definitions for what is called ALS and BLS, the study of partial ALS attitudes or techniques instead of the all concept analyses, small study samples, studies not controlled nor randomised and a retrospective methodology are probably the main reasons for the difficulty in showing a better relationship of ALS with outcome, along with differences between trauma systems.[13] The future of ALS pre-hospital trauma care depends on finding the groups of patients who benefit definitely from it. We believe that this study contributes to this debate as it shows that trauma patients transferred to a trauma centre benefit from ALS in the pre-hospital phase. Although studies comparing ALS with BLS have been done before as far as we know the comparison was never performed in a well-defined cohort where interventions were definitely needed to treat life-threatening events, as was the case in this study. Our study is in accordance with recent papers showing benefit of ALS in the pre-hospital environment[9,22,23] and others that show benefit from pre-hospital ALS only in specific groups of patients namely those with TBI.[24–27]

A recent before-after controlled clinical trial study from Canada[28] shows an increase in mortality with ALS implementation. Comparison with our report is difficult as the Canadian study compares ALS done by trained paramedics in urban scenarios. In our study ALS means the presence of a doctor that identifies and corrects the life-threatening events that each patient had in either rural or urban scenarios. Moreover they study only patients admitted directly from the scene and we are studying transferred patients.

Another important result is that this study strongly supports the importance of the ABCD methodology—a structured approach to assess and treat life-threatening events in trauma patients. ABCD methodology is currently taught in trauma courses like ATLS[15] and European Trauma Course.[29] This finding is in accordance with other authors like Deakin who found that preventable pre-hospital deaths were related to failure to deliver good solutions to A, B and C life-threatening events at the scene.[30]

We also report that correcting life-threatening events pre-trauma centre (pre-hospital and first hospital) increases the total time from the accident to trauma centre. The mean times we report were very long mainly not only because we are analysing only transferred trauma patients but also because the trauma system we are analysing has hospitals that are more than three driving hours away from the trauma centre. Several studies also found an increase in total pre-hospital time spent if ALS was dispatched to trauma patients.[31–33] Moreover some studies even reported a worse outcome if the time to trauma centre was prolonged.[5,6] However in our trauma system time from accident to trauma centre although also higher did not make a measurable difference in the mortality of severe trauma patients making us reject our second hypothesis. This is in accordance with other European studies from Scotland and Switzerland showing that long pre-hospital times were not associated with worse outcome.[7,23] We believe that the potential disadvantage of spending more time pre-trauma centre might have been diluted by the advantages of delivering good standards of care in the pre-hospital environment or first hospital correcting life-threatening events prior to transfer to the trauma centre.

### 4.1. Study strengths and weaknesses

Our study's strengths lie in the well described cohort of patients; the prospective evaluation of a single trauma system with all patients transferred and afterwards treated in the same trauma centre; the use of the TRISS methodology for severity analysis and the use of a regression modelling to adjust mortality for case mix.[34]

There are however a number of potential limitations in this study that must be taken into consideration. First, hospital mortality (more precisely trauma centre mortality), the dependent variable used, is a crude measure of effectiveness and may be heavily influenced by the quality of primary hospital care and possible differences in patient handling after reaching the trauma centre. Second we did not measure time from the traumatic event to treatment of life-threatening events and assumed that patients who had events solved in pre-hospital care had them solved earlier than patients who had them solved in primary or secondary hospital or trauma centre. We do not know this with certainty because the registry only records total time from injury till arrival in the trauma centre. However it is unlikely that patients assessed and treated in the pre-hospital phase, by an emergency physician, had their events corrected later than patients who were transported to first hospital and then transferred to trauma centre. Third we did not collect data on urban versus rural geography in our trauma system. A study from Liberman et al. showed no benefit of ALS in urban areas in Canada.[35] Other studies suggest benefit from pre-hospital ALS in rural and remote areas.[7,36,37] One possible explanation for our results would be that patients with life-threatening events corrected pre-trauma centre were predominantly from a rural area. Fourth we cannot make conclusions regarding the influence of pre-trauma centre correction of life-threatening events on pre-trauma centre mortality as this is a study based only on a trauma centre registry and not a population based study.

### *4.2. Conclusions and future research*

Interventions able to treat life-threatening events (especially if made early by pre-hospital ALS teams) decreased transferred trauma patient mortality even if this prolonged time to trauma centre. Further research should indicate whether this conclusion can be generalised to different trauma systems.

## Conflict of interest statement

All authors' deny any conflicts of interest.

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