Injury, Int. J. Care Injured 46 (2015) 602–609

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

The influence of prehospital time on trauma patients outcome: A systematic review

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ARTICLE INFO

Article history:
Accepted 7 January 2015

Keywords:
Prehospital
Time
Interval
Trauma
Patient
Outcome
Mortality
Systematic review

ABSTRACT

Objective: Time is considered an essential determinant in the initial care of trauma patients. Salient tenet of trauma care is the 'golden hour', the immediate time after injury when resuscitation and stabilization are perceived to be most beneficial. Several prehospital strategies exist regarding time and transport of trauma patients. Literature shows little empirical knowledge on the exact influence of prehospital times on trauma patient outcome. The objective of this study was to systematically review the correlation between prehospital time intervals and the outcome of trauma patients.

Methods: A systematic review was performed in MEDLINE, Embase and the Cochrane Library from inception to May 19th, 2014. Studies reporting on prehospital time intervals for emergency medical services (EMS), outcome parameters and potential confounders for trauma patients were included. Two reviewers collected data and assessed the outcomes and risk of bias using the STROBE-tool. The primary outcome was the influence on mortality.

Results: Twenty level III-evidence articles were considered eligible for this systematic review. Results demonstrate a decrease in odds of mortality for the undifferentiated trauma patient when response-time or transfer-time are shorter. On the contrary increased on-scene time and total prehospital time are associated with increased odds of survival for this population. Nevertheless rapid transport does seem beneficial for patients suffering penetrating trauma, in particular hypotensive penetratingly injured patients and patients with a traumatic brain injury.

Conclusion: Swift transport is beneficial for patients suffering neurotrauma and the haemodynamically unstable penetratingly injured patient. For haemodynamically stable undifferentiated trauma patients, increased on-scene-time and total prehospital time does not increase odds of mortality. For undifferentiated trauma patients, focus should be on the type of care delivered prehospital and not on rapid transport.

Introduction

Trauma is one of the major causes of death worldwide; approximately five million people die each year as a result of traumatic injuries. In the USA alone, trauma is the leading cause of death for Americans under the age of 40 [1]. In 2011 road traffic injuries claimed nearly 3,500 lives each day worldwide [2]. Emergency medical systems (EMS) around the world are constantly evolving in order to reduce these numbers and provide better quality medical care. To do so, focus has often been on shortening prehospital times [3]. Historically, time is considered to be an essential determinant on the outcome of trauma patients. A fundamental tenet of trauma care is the 'golden hour', the immediate time after injury when resuscitation, stabilization and rapid transport are perceived to be most beneficial to the patient [4]. It is thought that when advanced emergency medical care is provided in this brief window of time and this time interval is kept to a minimum, mortality and morbidity of the trauma patients will be reduced [5–8]. However, not all trauma literature is in concordance on this matter [9,10]. In many emergency medical systems patients spend this extremely important time-interval in a prehospital setting, without receiving definitive care [11]. Though

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http://dx.doi.org/10.1016/j.injury.2015.01.008
0020–1383/

it seems intuitive to transport a trauma patient as fast as possible to a trauma centre, especially those with a severe haemorrhage or increasing intracranial pressure, this may have adverse effects on the outcome, as some patients may be in need of specialized care before transfer [9,12]. There is discussion on the exact influence of the duration of time elapsed before reaching a trauma centre on patients outcome. Many of the scientific findings concerning prehospital times derive from studies done in war settings with military systems of care [13]. Whether or not this can be extrapolated to civilian trauma care, has not fully been investigated. Different ideas exist with regard to geographical factors, the mechanism of injury (MOI) and swiftness of transfer [14]. Timely transfer is thought to be a critical predictor of outcomes for patients with acute traumatic injuries in rural and developing regions. And also for the penetrating injuries where the concept of 'scoop and run' is often implemented. Several studies have tried to investigate the effect of prehospital time intervals on patient outcome [15–17]. So far, no study has systematically reviewed the effect of the prehospital time intervals on outcome parameters for trauma patients. The objective of this study was to systematically examine and review the influence of different time intervals in the prehospital phase on outcome measurements for trauma patients. Our aim is to provide a thorough summary of the current relevant literature.

Methods

This systematic review was performed according to the recommendations of the preferred reporting items for systematic reviews and meta-analysis (PRISMA statement [18]).

Searches and data sources

To identify all relevant publications systematic searches were performed in collaboration with a medical research librarian, in the bibliographic databases PubMed, Embase.com and The Cochrane Library (via Wiley) from inception to May 19th 2014. Search terms included controlled terms from MeSH as well as free text terms in PubMed, EMtree in EMBASE.com. We used free text terms only in The Cochrane library. Search terms expressing 'trauma patients' were used in combination with search terms comprising 'on-scene time' and 'outcome parameters'. The references of the identified articles were searched for relevant publications. The search strategy in PubMed can be found in Supplementary Data file 2. We applied a language restriction; English, German and Dutch articles were included. The search was further limited to articles with an abstract available and we only included observational studies, as our goal was to observe the normal standard of care delivered without intentionally altering care in order to test an intervention. The separate results from all searches were reconciled for duplicate articles. All searches were conducted by two investigators with prior experience in conducting a systematic review (A.H., E.J.).

Selection of studies

We included studies that reported criteria concerning prehospital EMS time intervals for trauma patients (1); this could mean either one of the following intervals: on-scene time or total prehospital time and when also available activation interval, response time and transfer time. Definitions of the time intervals used are portrayed in Table 1. The studies had to investigate the influence of the length of prehospital times on outcome parameters (2). Adequate information had to be provided on outcome parameters such as; length of hospital admission, length of ICU admission or mortality. Definitions of prehospital time intervals and outcome measurements had to be clarified (3).

Table 1
Definitions of prehospital time intervals.

Prehospital time interval	Abbreviation	Definition
Activation time	AT	Time required for EMS to deploy after emergency call
Response time	RT	Includes the AT and the time to get to the scene of accident
On-scene time	OST	Time spent on scene by EMS
Transport time	TT	Time from departing scene to arrival at the hospital
Total prehospital time	TPT	Total time between emergency call and arrival at the hospital

Exclusion criteria were articles with insufficient information (1), for example, very limited or only gross information on prehospital transport time intervals. Article with duplicates of previously published data (2), articles with no full-text available (3), comments (4), editorial (5), studies that did not adjust and/or report on confounders (6) or inadequate statistical analysis (7), were also excluded. The abstracts obtained by the search were independently reviewed for suitable articles by two reviewers (A.H., P.M.). If suitable the full-text versions were retrieved. Furthermore we hand searched the reference-list of included publications and the subject indices of prominent journals to identify further suitable articles. Two investigators (A.H., P.M.) independently assessed all full-text articles to ensure that the inclusion criteria were met. Any discrepancies between the reviewers about the articles meriting inclusion were resolved by consensus after deliberation with a third investigator (G.G.).

*Data **extraction and management***

The following data were extracted from the studies when available: title, year of publication, location of study, study design, number of patients, MOI, age and gender of participants, prehospital time interval: activation time (AT), response time (RT), on-scene time (OST), transfer time (TT) or total prehospital time (TPT). The outcome parameters extracted when available were mortality, hospital length of stay (LOS), days of admission to the ICU and complications (as reported by the American College of Surgeons (ACS)). When an included study did not supply the necessary information the authors were contacted by e-mail to provide the additional information. Unfortunately many of the authors addressed were unable to supply us with the requested information. We attempted to perform a meta-analysis with the available and acquired data to combine results and to estimate more the true effect size. However, due to heterogeneity of the analyses used, inability to extract data from the papers and inadequate information provision, this could not be achieved.

Assessment of methodological quality and risk of bias

The methodological quality of each included paper was assessed by two independent reviewers (A.H., G.G.) using the elaborate STROBE-statement for non-randomised observational studies [19]. The level of evidence of each article was scored using the grading system for level of evidence from the Centre for Evidence-Based Medicine [20]. The levels of evidence range from one, which entails high-quality evidence up to five, which entails poor quality evidence or expert opinion. Discrepancies were thoroughly discussed and resolved by consensus.

Results

The search yielded a total of 2,938 potentially relevant articles. After removing duplicates of references that were selected from more than one database, 2,876 references remained. We discarded 2,830 on title or abstract because they were not relevant. The full-text articles of the remaining 46 were retrieved: 26 studies were excluded from further analysis; one due to duplicity of data, 15 were discarded due to improper or no relationship between variables of interest, one was not on topic and nine wrote on a non-trauma patient population. The flow chart of the search and selection process is presented in Fig. 1. Finally, twenty observational studies were included in the review. Of which nine were prospective and eleven were retrospective. The overall quality of the included studies was judged "high risk of bias" (no or insufficient reporting on the item), "unclear risk of bias" (unclear manner of reporting) or "low risk of bias" (appropriate manner of reporting on the item). This was done for all 22 items of the STROBE instrument (Fig. 2). Eleven individual items were judged as low risk of bias for all studies. High risk of bias items often included: lack of reporting potential sources of bias and not reporting on how missing data was handled in the methods section; not reporting on reasons for non-participation at each stage of the study, failing to use a flow diagram and failing to indicate the number of participants with missing data for each variable. Two individual items were judged not applicable for all included studies. The entire list of strobe item ratings per study is available in Supplementary data file 3. All studies were classified as level of evidence three. This entails individual case-control studies, of consecutive or non-consecutive nature; or without consistently applied reference standards. The selection of patients in all studies was by consecutively admitted trauma patients, in order to ensure appropriate representativeness and minimizing selection bias. The studies obtained data from either a government department concerned with trauma care registry, hospital trauma registries, police motor vehicle crash data or outcomes of the consortium epidemiologic out-of-hospital trauma. Table 2 presents an overview of the characteristics of included studies.

Activation time (AT)

In the study by Kidher et al. [21] the authors were unable to find a statistical significant effect of AT in quintiles on mortality in severe thoracic trauma patients. Newgard et al. [22] were also unable to demonstrate independent association between mortality and activation interval in adult trauma patients.

Response time (RT)

Of the included studies six report on influence of the duration of RT on mortality. Three studies report on undifferentiated trauma patients [6,16,22]. Feero et al. [6] and Gonzalez et al. [16] show a prolonged RT is associated with higher mortality. Feero et al. [6] use the TRISS methodology to calculate the probability of survival (POS), this was used to calculated the unexpected survivors; those who survived despite a POS <50% and the unexpected deaths; those who died despite a calculated POS >50%. Feero et al. shows RT to be shorter for unexpected survivors versus unexpected death. Gonzalez et al. divided the included patients into urban or rural groups for analysis and report that longer RT was significantly

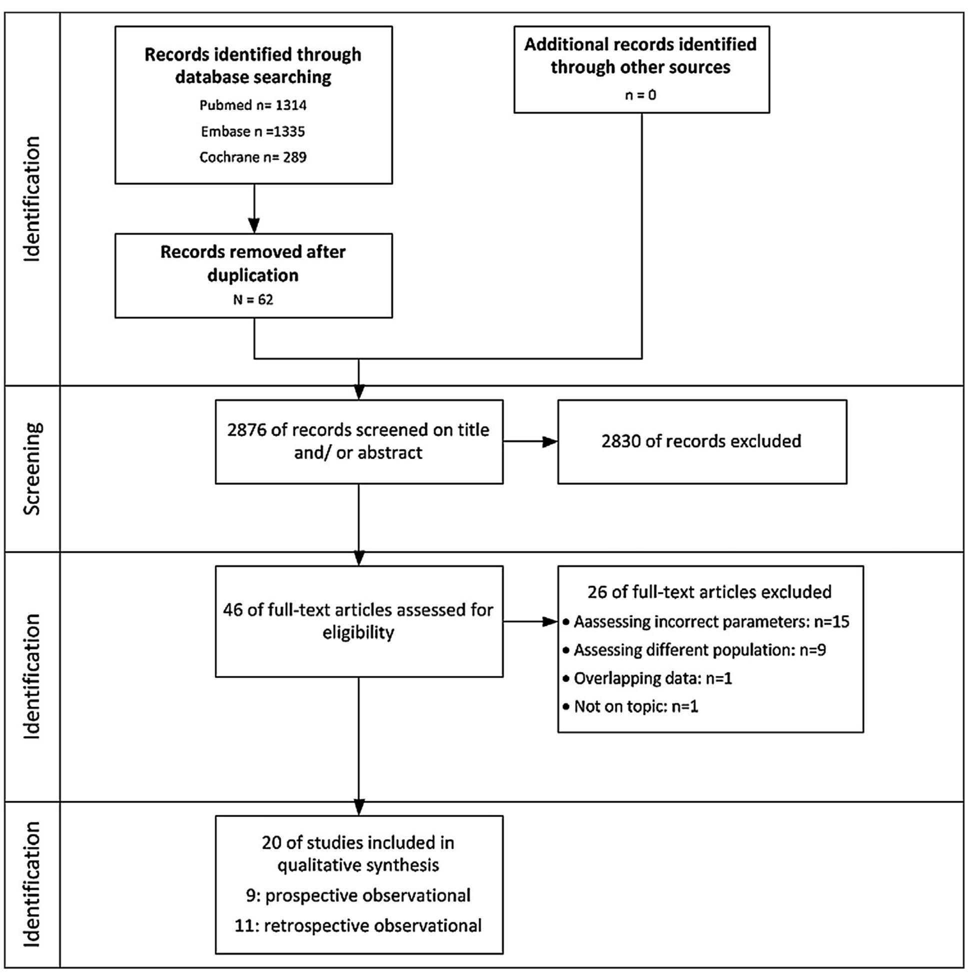

Fig. 1. Flowchart: n = number of articles.

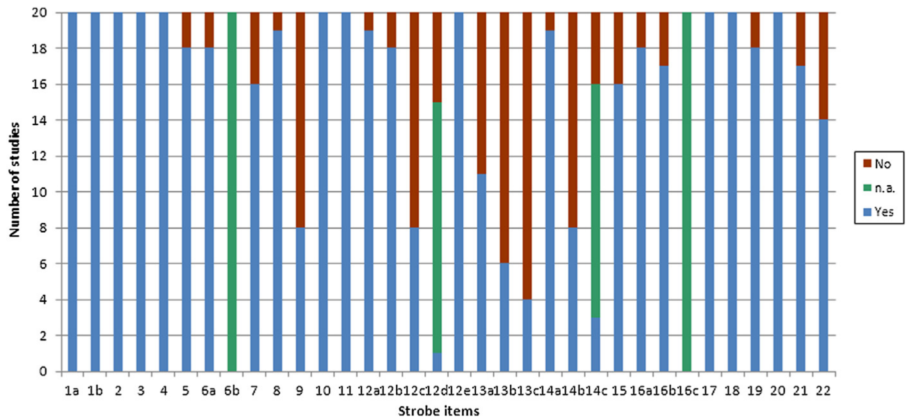

Fig. 2. STROBE: No: not reported, n.a. not applicable to the study, Yes: reported in the article.

associated with increased mortality in rural settings, though this was not seen in the urban setting. However, Newgard et al. [22] were unable to show an association between mortality and RT. Three studies report on the influence of RT in thoracic injured patients [21,23,24]. Kidher et al. [21] show no significant effect of RT on mortality. Funder et al. [23] likewise show no significant association for patients suffering penetrating trauma to the thorax, abdomen and/or neck.

On-scene time (OST)

Ten of the included studies report on influence of the time spent on-scene on mortality. Five of the studies report on undifferentiated trauma patients. Feero et al. [6] report no statistically significant difference in OST between unexpected survivors and deaths. Newgard et al. [22] show no association. Ringburg et al. [17] state that HEMS care is associated with a 9.3 min longer OST but after adjusting for confounders mortality was equal for the EMS and EMS/HEMS groups. Gonzalez et al. [16] report similar OST for survivors and nonsurvivors in an urban setting. However in the rural setting they report that OST was significantly longer for nonsurvivors. Though Petri et al. [12] report that mean OST was significantly lower among decedents, they stratify patients into groups on the basis of ISS. Four studies report on patients suffering penetrating injuries. Eachempati et al. [25], Funder et al. [23] and Honigman et al. [26] report that the OST did not differ significantly between survivors and nonsurvivors. In contrast McCoy et al. [27] show patients with penetrating injuries with an OST $\geq$20 min have a higher odds ratio of mortality versus patients with OST $<$10 min. OST of 10–19 min was not significantly associated with mortality. McCoy et al. [27] also report on patients suffering blunt force trauma. They were unable to show an association between OST and an increase in odds ratio of mortality. Kidher et al. [21] report on patients suffering thoracic trauma. They report no significant difference between survivors and nonsurvivors for OST.

Transport time (TT)

Nine of the studies report on influence of TT on mortality or days of hospital admission. Five studies report on undifferentiated trauma patients. Feero et al. [6] show no significant difference between unexpected survivors versus unexpected deaths, Newgard et al. [22] also fail to show a significant association between mortality and TT in minutes. However Gonzalez et al. [16] and Petri et al. [12] show that nonsurvivors have a significant shorter TT. McGuffie et al. [28] divided the included patients into urban or rural groups for analysis, they report no association in both rural and urban setting between mortality and TT. However they did show TT to be a significant factor when total length of hospital stay was modelled, longer TT was associated with a longer hospital stay. Three studies report on patients suffering penetrating trauma. Eachempati et al. [25] and McCoy et al. [27] show no increased odds of mortality for longer TT. However, Swaroop et al. [24] show significantly shorter TT for hypotensive patients versus normotensive patients. No correlation is made with mortality. Kidher et al. [21] report no statistically significant effect of TT on mortality for thoracic trauma. McCoy et al. [27] also report on blunt injury, they were unable to find an association between TT and mortality.

Total prehospital time (TPT)

Sixteen of the included studies report on the effect of TPT on mortality. Six studies report on undifferentiated trauma patients. Beaz et al. [29] uses a division between young patients, below 65 years of age, and elderly patients, equal or above the age of 65. They report that TPT did not correlate significantly with mortality, not for young patients and not for elderly. Newgard et al. [22] also fail to show an association for increasing TPT with mortality using multivariable logistic regression, even when assessed as quintiles or dichotomised (above or below 60 min). Ryb et al. [30] report that the odds of survival were slightly higher for TPT longer than 60 min. Same as the results found by Brooke et al. [31], however for their analysis they use a division based on CUPS-status and find that survivors have a significantly longer mean TPT than nonsurvivors. Though multiple predictors' logistic regression fails to show TPT as significant predictor of mortality. Petri et al. [12] also report that mean TPT was significantly lower among decedents than survivors. Contradicting, Feero et al. [4] report that TPT was significantly shorter for unexpected survivors than for unexpected death. Three studies report on patients suffering penetrating trauma. Swaroop et al. [24] report an increased OR of death with increasing TPT for hypotensive patients with penetrating thoracic injuries. Conversely the normotensive patients exhibited decreased mortality with longer TPT. However, Pepe et al. [9] show that survival did not change significantly with increasing TPT, they use the TRISS methodology to calculate the POS. McCoy et al. [27] also found that longer TPT is not associated with increased mortality. McCoy et al. [27] also report on patients suffering blunt force trauma. Here they also report no association between TPT and mortality. Osterwalder et al. [32] likewise analyzes blunt force trauma patients. They compare 30-day mortality with predicted mortality, based on a severity characterization of trauma (ASCOT) score [33] and finds 30-day mortality was higher in the group with a TPT $<$60 min compared with TPT

Table 2
Study characteristics.

Author Country Year	Database Study type	Type of trauma pt, sample size	Confounders	Outcome: correlation between time interval and outcome
Beaz USA 2006	DOH Retrospective	Adult (ISS > 15) n = 1.866	Gender, age, ISS, RTS,	↑ TPT – ↑ LOS (p = .001) ↑ TPT–↑ Comp (p = .016)
Brooke USA 2003	RTD Retrospective	Adult n = 1.877	Age, ISS, RTS, CUPS	TPT – Mort: non sig (OR 0.987, 95% CI 0.97–1.00, p = .023)
Dinh AUS 2012	RTD Retrospective	Adult TBI (AIS ≥ 3) n = 983	Age, GCS, ISS, hypotension, need for craniotomy	↑ TPT – ↑ Mort (HR 1.002, 95% CI 1.001–1.004, p = .001). Survival benefit TPT < 90 min (OR 0.35, 95% CI 0.18–0.65, p = .001)
Eachempati USA 2002	RTD Prospective	Penetrating abdom/vasc n = 36	BD, BP, NVI, EBL	OST – Mort: non sig (p = .105) TT – Mort: non sig (p = .651)
Feero USA 1994	SIR Retrospective	Major trauma n = 848	TRISS	RT/OST/TT/TPT – sig ↓ for unexpected survivors (resp. p = .04, p = .06, p = .17, p = .02)
Funder DK 2010	RTD Retrospective	Penetrating neck/ thorax/abdomen n = 467	Age, gender, RT, OST, TT, ISS,	RT – Mort: sig (p = .04) OST – Mort: non-sig (OR 3.71, 95% CI 0.66–20.70, p = .14)
Gonzalez USA 2009	SIR Prospective	Crash victims n = 45.763	Urban/rural	Survivors: ↓ RT (p = .0001) Survivors: ↓OST (p = .0014) Mortalities: ↓ TT (urban p = .0056, rural p = .0002)
Härtl USA 2006	SIR Retrospective	TBI (CGS < 9) n = 1.123	Age, pupillary status, SBP, GCS	TPT – Mort: non-sig (OR 1.00, 95% CI 1.00–1.00, p = .25)
Honigman USA 1989	RTD Prospective	Penetrating cardiac n = 70	N= procedures, n= IV lines, EI, PASG, RTS	OST – Mort: non-sig (p = .20)
Kidher UK 2012	RTD Retrospective	Thoracic n = 688	ISS, TOI	TPT > 65 min OR 1.43 on Mort (95% CI 0.52–3.92, p < .001)
McCoy USA 2013	RTD Prospective	General n = 19.167	Age, ISS, RTS, MOI	OST ≥ 20 min ↑Mort (OR 2.90, 95% CI 1.09–7.74)
McGuffie 2005 UK	SIR Prospective	ISS > 8 n = 4.531	Age, ISS, RTS, MOI, TOI, type of care, geographic	RT/OST/TT–Mort/LOS: non-sig
Newgard USA 2010	NTD Prospective	Adult n = 3.656	Age, RTS, ALS/BLS, TOI, GCS, BP, HR, EI	No sig association between time and mortality for AT(OR 1, 95% CI 0.95–1.05), RT(OR 1, 95% CI 0.97–1.04), OST(OR 1, 95% CI 0.99–1.01), TT (OR 1, 95% CI 0.98–1.01), TPT(OR 1, 95% CI 0.99–1.01)
Osterwalder CH 2002	SIR Prospective	Blunt n = 254	ASCOT, MOI, OSP, EI	Mort higher TPT < 60 min compared with TPT > 60 min (OR 8, 95% CI 1.7–38.5)
Pepe USA 1987	RTD Prospective	Hypovolemic penetrating n = 498	TS	Survival did not change significantly with increasing TPT
Petri USA 1995	RTD Retrospective	General n = 5.215	ISS, time variables	OST, TT and TPT sig shorter among nonsurvivors (all p-values <.001)
Ringburg NL 2007	RTD Prospective	General n = 1.457	Age, RTS, ISS, day-time, MOI	No higher chance of mort with increasing mort (OR 1, 95% CI 0.8–1.3, p = .89)
Ryb USA 2012	NTD Retrospective	Adult n = 192.422	EMS/HEMS, RTS, ISS	Survival higher for TPT >60 min (OR 1.68, 95% CI 1.52–1.87).
Swaroop USA 2013	SIR Retrospective	Penetrating thoracic n = 908	Age, race, ISS, BP	↑TT – ↑mort hypotensive pt 0–15 min (OR 3.87, 95% CI 0.1.45–10.28), 16–30 min (OR 5.90, 95% CI 4.42–7.88) 31–45 min (OR 8.99, 95% CI 5.35–15.11), 46–60 min (OR 13.00 95% CI 1.98–85.46). For normotensive pt showed ↓ mort with ↑ TT (OR 0.93, 95% CI 0.83–0.99, p < .001).
Tien CA 2011	RTD Retrospective	ASDH n = 149	Age, gender, GCS, OSP, ISS, SAH, ICH,	Sign association TPT – mort (OR 1.03, 95% CI 1.004–1.05, p = .024)

DOH: Department Of Health, n = number, RTS: revised trauma score, TPT: total prehospital time, LOS: length of stay, Comp: complication, RTD: regional trauma database, CUPS: critical unstable potentially unstable stable-tool, Mort: mortality, sig: significant, TBI: traumatic brain injury, AIS: abbreviated injury scale, GCS: Glasgow coma scale, BD: base deficit, BP: blood pressure, NVI: non-vascular injuries, EBL: estimated blood loss, OST: on-scene time, TT: transport time, SIR: state injury registry, TRISS: trauma and injury severity score, RT: response time, SBP: systolic blood pressure, EI: endotracheal intubation, PASG: pneumatic anti-shock garments, TOI: time of incident, MOI: mechanism of injury, NTD: national trauma database, ALS: advanced life support, BLS: basic life support, HR: heart rate, ASCOT: a severity characterization of trauma, OSP: on-scene physician, TS: trauma score, (H)EMS: (helicopter) emergency medical services, ASDH: acute traumatic subdural haematoma, SAH: subarachnoidal haematoma, ICH: intracerebral haemorrhage.

>60 min. Kidher et al. [21] divided their cohort of thoracic injured patients in two groups; those with TPT above 65 min and those with TPT below 65 min. They show increased odds of mortality for the group with a TPT above 65 min. Three studies report on patients who suffered TBI. Tien et al. [34] show a nonsignificant trend using multivariate logistic regression analysis, suggesting that patients who arrived within the 'golden hour' had a lower mortality than those outside of the 'golden hour'. Dinh et al. [15] report a rise in mortality with increasing TPT. They fail to show an association between mortality and the 'golden hour' or arrival <30 min. They report survival benefit for patients arriving <90 min. Härtl et al. [35] find TPT not to be related to 2-week mortality in severe TBI patients.

Limitations

It is difficult to solely address the effect of time spent in a prehospital setting on trauma patient outcome because several factors are of influence. This is reflected in the heterogeneity of the included studies. For one, patients are divided into various categories for analyses and use different types of trauma score to allocate patients. Second there are dissimilarities in included trauma mechanisms. Included subgroups are patients with penetrating injuries, blunt force trauma, TBI patients or undifferentiated trauma patients which include all before mentioned categories. Furthermore, geographic and logistic factors have an apparent influence on time spent prehospital, one could imagine these factors to differ for each country or trauma system. An American study [36] shows that increased EMS RT and OST as well as increased distance to the scene were contributing factors to increased mortality in rural crashes. Correspondingly another factor to consider is the type of care delivered prehospital. One could imaging trauma patient outcome is different when receiving A(T)LS versus B(T)LS. Assistance of a physician or advanced critical care paramedics may lead to improved survival rates but prolong prehospital times. Härtl et al. [35] found no significant difference in mortality comparing ALS versus BLS. They also did not find a difference between air- or ground transport. Ringburg et al. and Ryb et al. [17,30] likewise assessed if transport mode, HEMS or EMS, was of influence on prehospital time of mortality. Furthermore one could hypothesize that due to changing therapies and treatments over time (for example: rapid sequence intubation, widespread access to helicopters), the older included studies report on different approaches than the newer. This may impact prehospital time intervals as well as outcome. The studies included are level III evidence [20] and thus are subject to various limitations: (i) of the included studies several were retrospective studies and are prone to selection bias and misclassification. (ii) All of the presented studies are without a control group. (iii) Two studies have limited number of patients included [25,26]. (iv) There is lack of uniformity in definitions on intervals used, type of analysis and definition of outcome. The usage of inhospital-mortality as outcome parameter in some studies may have led to under reporting of mortalities. We acknowledge these limitations; consequently the findings in this review should be regarded with caution. For future research we recommend using prehospital intervals as suggested by Carr et al. [37] in a meta-analysis of prehospital care time, in which they purpose a standardized evaluation of prehospital times. Furthermore we recommend usage of 30-day-mortality. This seems the most reliable outcome parameter, because it includes the majority of surgery-related deaths and is not subject to discharge procedures [38]. However, because of the retrospective nature of many of the included studies this was not feasible.

Discussion

Trauma patient outcome and the relationship with prehospital time intervals are of interest to investigate. Historically emphasis has been on time and many of the changes in trauma care are based on the tenet that shorter prehospital times are better for the trauma patient, though little is empirically known on this matter. Carr et al. [37] performed a meta-analysis on prehospital care times. They provide an average duration for each time interval but do not correlate length of the interval with outcome measurements of the trauma patient. To the best of our knowledge, this is the first systematic research addressing this relationship. When reviewing the impact of RT, it seems that a shorter RT has a positive influence on mortality for undifferentiated trauma patients. This could be explained by timely medical assistance. Though, Weiss et al. [39], who specifically examined response time influence in trauma patients, found no correlation. When looking at OST, this is a time interval that is of special interest since this is the prehospital time interval depending on the performance of the prehospital caregiver and therefore the interval one can best influence. However, for undifferentiated trauma patients, four out of five included studies showed no influence of time spent at the scene of the accident on mortality [6,16,17,22]. Only Petri et al. [12] report that mean OST was significantly lower among decedent. When assessing the OST for patients suffering penetrating or blunt trauma, included studies showed no correlation. McCoy et al. [27] showed a positive effect of shorter OST in patients suffering penetrating trauma. This could be explained by the fact that treatment of exsanguination often requires radiological imaging and surgical interventions due to the anatomical complexity and non-compressible nature of the large vessels. Gonzalez et al. [16], Petri et al. [12] and McGuffie et al. [28] showed TT to be a significant factor of influence on mortality as well as on length of hospital stay in undifferentiated trauma patients. Possibly because it is expected to lead to more effective care sooner. For patients suffering penetrating or blunt force trauma no association between TT and survival could be found. Looking at TPT in trauma patients Ryb et al., Petri et al. and Lerner et al. [12,30,31] show that the odds of survival were slightly higher for longer TPT. When looking at TPT in patients suffering penetrating trauma two studies fail to show a significant change in survival with increasing TPT. However, Swaroop et al. [24] report an increased risk of death in hypotensive patients with increasing TPT and a decreased risk of mortality for normotensive patients with increasing TPT. When reviewing blunt force trauma patients one out of two studies report no association. Nevertheless, Osterwalder et al. [32] found mortality was higher with a shorter TPT. For TBI patients increased TPT seems to be related with an increase in mortality. This could be explained due to the fact that this group of patients is often in need of emergency neurosurgical interventions, such as craniotomy, which cannot be performed in the prehospital setting. When further examined expressions such as 'golden hour' three of the included studies report on this matter. Dinh et al. [15] report there was no survival benefit observed for TBI patients arriving within 60 min of injury. Tien et al. [34] likewise report on TBI patients and show a strong trend suggesting that patients arriving within 60 min of injury have a decreased mortality. Osterwalder et al. [32] report no difference in mortality between patients arriving within 1 h or after 1 h. This is in concordance with some of the literature found [4,5,7,8,10]. Though we are under the impression time is best to be analysed as a continuous variable or at best grouped in intervals. Since the cut-off is relative arbitrary and information is lost when continuous data are transformed to dichotomous data [40]. Four of the included studies use time clustered in various categories when not considered a continuous variable [9,15,27,34]. Reviewing treatment modalities such as scoop-and-run and stay-and-treat strategies, Ringburg et al. [17] report an unsurprising higher OST for the stay-and-treat group due to factors concerning helicopter emergency medical services (HEMS) care. Longer OST in stay-and-treat does not improve outcome but return the mortality rate to that of the scoop-and-run group. However, because no increased mortality could be demonstrated there is no reason to transport sooner than current protocol in the stay-and-treat group. This demonstrates the idea that interventions performed on-scene and their duration are of great influence on the outcome of a trauma patient [41].

Conclusion

For undifferentiated trauma patients a shorter RT and TT may have a positive influence on mortality. However, it seems that a longer OST may increase odds of survival. The same trend is seen in TPT which is probably due to the relatively large share of OST in total TPT. This increased odds of survival with longer OST is presumably related to the comprehensive care that is delivered prehospitally, implying that for the future, the emphasis should not be on getting a patient to the hospital as fast as possible but making sure the patients receive proper prehospital care first. However, swiftness of transport is beneficial for TBI patients and patients suffering penetrating trauma, especially those who are hypotensive. The relatively low level of evidence of the included studies highlights the need for more, well designed studies to be able to fully assess the risk of time spent prehospitally on trauma patient outcome.

Conflict of interest

All authors declare there are no conflict of interest to report.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.injury.2015.01.008.

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