Lights and Siren Transport and the Need for Hospital Intervention in Non-Trauma Patients: A Prospective Study

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Abstract

Background: The use of lights and siren transport (LST) has been a matter of debate because of the short time savings and well-established increased risks for Emergency Medical Services (EMS) and bystanders. Time-critical hospital intervention (TCHI) denotes urgently needed procedures that cannot be performed properly in an out-of-hospital setting. Since 2013, rapid transportation from the field – fast-track – is currently used for patients with acute ST-elevation myocardial infarction, suspicion of acute stroke and out-of-hospital cardiac arrest. We aimed to determine whether the use of LST was associated with the realization of TCHI for non-trauma cases within 15 minutes of hospital arrival, to identify the predictors of TCHI and to compare clinical outcomes in patients transported with or without LST.

Methods: This is a monocentric prospective observational study of non-trauma patients transported by ambulance. Based on Ross et al.’s work in 2016 on trauma patients, TCHI procedures were developed by the study team. We used descriptive statistics to determine whether the use of LST was associated with the realization of TCHI. Univariate and multivariate analyses determined the predictors of TCHI and compared clinical outcomes.

Results: On the 324 patients included, 67 (20.7%) benefitted from LST, with 40 (59.7%) receiving TCHI (p < 0.001). The most common medical TCHI was the fast-track (65.2% of all TCHI). LST was predictive of the need for TCHI (p < 0.001), as was the clinical condition of the patient and also when EMS providers expected TCHI. When transported with LST, patients were hospitalized significantly more often in acute care units and less often in general wards or discharged from the Emergency Department (p < 0.001).

Conclusions: The use of LST for non-trauma patients was positively associated with the realization of TCHI. EMS providers demonstrated a high level of precision in discerning which patients deserved LST. A majority of the LST benefitted from TCHI. Nevertheless,
when fast-track was excluded the rate dropped by more than 50%. To reduce the rate of over-triage (LST without TCHI), LST should be used only for fast-track and also when TCHI is expected by the EMS providers.

Background

The prehospital lights and siren transport (LST) of patients from the field to the hospital has been a matter of debate for several years. LST is perceived as a method for reducing travel time between the field and the hospital [1,2]. On the other hand, LST is potentially associated with an increased risk of collision and injury to Emergency Medical Services (EMS) providers, patients and bystanders [1–7]. Furthermore, the time saved – a couple of minutes – is considered moderate, with no clinical benefit demonstrated to date [8–11].

There is currently no consensus on what would be an appropriate use of LST from the field to the hospital, and LST criteria for use are rarely defined in EMS protocols. A relatively simple way to assess LST adequacy has been to consider it appropriate when dealing with a potentially life-threatening situation [11–14]. Some studies have applied a more comprehensive approach, using the application of time-critical hospital intervention (TCHI) as an endpoint to indicate the appropriateness of LST [2,9,10,15]. TCHI is defined as those procedures or treatments that are urgently needed, requiring skills or devices that are either not available or cannot be properly performed in the prehospital setting [2,8,10]. Recent studies have demonstrated that up to a quarter of life-threatening situations, such as airway obstruction, severe dyspnoea, hemodynamic instability and abnormal Glasgow Coma Scale, require TCHI [8-10]. As proposed by the American Heart Association and the American Stroke Association since 2013, acute ST-elevation myocardial infarction (STEMI), suspicion of acute stroke and out-of-hospital cardiac arrest (OHCA) require rapid transportation from the field (fast-track) to benefit from an urgent procedure and therefore also may be considered as TCHI [16-18].

Most studies on TCHI were retrospective and centered on trauma cases. As non-trauma cases represent the majority of EMS case-mixes, based on a previous work on trauma patients [8], the present study aimed to assess prospectively the association between the use of LST and the rate of TCHI performed within the first 15 minutes of emergency department (ED) arrival on non-trauma cases, as well as the predictors associated with TCHI and the clinical outcomes.
Methods

This monocentric prospective observational study was conducted from October 2016 to April 2018 in the ED of Lausanne University Hospital in the State of Vaud, Western Switzerland (~794,000 inhabitants in 2017). This Level-1 trauma centre has 1400 beds, and its ED provides 42,000 consultations per year. A unique medical dispatch centre coordinates the State’s EMS crews. Paramedics use the State protocols for autonomous intravenous access, cardiopulmonary resuscitation procedures, defibrillation and emergency medication administration (acetylsalicylic acid, adrenaline, amiodarone, clonazepam, diazepam, fentanyl, glucagon, glucose, isosorbide dinitrate, midazolam, morphine, naloxone, paracetamol, salbutamol and thiamine) [19]. The decision to use LST for transportation from the site is left to the discretion of the EMS crew [11]. Its use allows the EMS crew to break normal traffic laws but with extreme caution. As patients arrive at the hospital, ED physicians do not know if the EMS crew used LST.

All patients arriving by ambulance at the ED were eligible. Trauma patients, hospital transfers and patients under 16 years old were excluded. As we did not have the resources to follow all patients individually for the duration of the study, we used a convenience sampling method [20]. During their shifts, two research nurses and a medical student screened as many consecutive patients transported to the ED as possible.

As for trauma cases, TCHI procedures for non-trauma patients were not clearly defined or validated in the literature at the time of the study. The study team therefore adapted a list developed by Ross et al. [8] (Table 1).

Table 1: List of TCHI procedures to be performed within 15 minutes of arriving at hospital
1. Airway and/or respiratory support procedures

| Procedure                          |
|------------------------------------|
| Patient intubation                 |
| Mechanical ventilation             |
| High frequency jet ventilation     |
| Tracheostomy                       |
| Cricothyroidotomy                  |
| Thoracocentesis                    |
| Chest tube placement               |
| Non-invasive ventilation           |

2. Invasive vascular procedures

| Procedure                          |
|------------------------------------|
| Central line                       |
| Arterial line                      |
| Dialysis catheter                  |
| Endovenous pacemaker               |
| Embolization                       |

3. Intensive therapeutic medical procedures

| Procedure                          |
|------------------------------------|
| Cardiopulmonary resuscitation      |
| Extracorporeal membrane oxygenation|
| Shock management (rapid fluid administration, vasopressors) |
| Emergency medication (antihypertensives, vasodilatators, antiarrhythmics, antiepileptics) |
| External pacing                    |
| Intoxication treatment – antidote administration |
| Active rewarming                   |
| Transfusion, frozen fresh plasma, Factor VIIa or prothrombin complex concentrate |

4. Fast-track

| Procedure                          |
|------------------------------------|
| STEMI fast-track                   |
| Stroke fast-track                  |
| OHCA fast-track                    |

Legend: STEMI: ST-elevation myocardial infarction; OHCA: out-of-hospital cardiac arrest.

The following prehospital variables were collected: gender; age; duration and distance of transport from the field; and the use of LST. Age was dichotomized (<65 vs. ≥ 65 years).

In order to study those variables that may affect the delay and realization of TCHI, EMS providers were asked after each intervention if they expected TCHI to be performed. TCHI foreseen by the EMS providers was defined as “expected TCHI” and that performed was defined as “validated TCHI”. EMS providers estimated the severity of non-trauma cases using the National Advisory Committee for Aeronautics (NACA) score, which comprises eight categories ranging from 0 (no injury or disease) to 7 (lethal injuries or disease, with or without resuscitation attempts). A NACA score of ≥ 4 implies a potential life-threatening condition [21,22].

The following hospital variables were collected: time interval between arrival in the ED and the first TCHI; TCHI performed within the first 15 minutes; in-hospital length of stay (LOS); hospital mortality; and disposition after ED management in intensive care unit (ICU), intermediate care unit (IMCU) or general ward (GW). An arbitrary cut-off of 15 minutes for TCHI was chosen based on previous studies [8,15].
Data were retrieved from the patient information database that was established for this study and analysed with the Statistical Package for the Social Sciences (SPSS), version 25 (IBM Corp., Armonk, NY).

As appropriate, data were described as frequency, mean and standard deviation (SD) or median and interquartile range (IQR). Descriptive statistics were used to analyse the frequency of LST use. Univariate analysis (including Student’s t-test and Pearson’s chi-square test) and multivariate analysis (including logistic regression) were used to determine variables associated with the receipt of TCHI: patients’ age and gender; LST; NACA score; and expected TCHI. Odds ratio (OR), lower and upper confidence intervals (95%CI), sensitivity, specificity and positive and negative predictive values (PPV, NPV) were calculated. A p value of < 0.05 was considered to indicate statistical significance.

Results

A total of 324 patients were enrolled between October 2016 and April 2018. Thirteen patients were transferred from the ED to regional hospitals for continuation of care so their post-ED care and mortality data could not be collected. The mean age of the sample was 65 ± 22 years and 160 (49.4%) were male. Sixty-seven patients (20.7%) were transported with LST, 40 (59.7%) of whom benefitted from at least one TCHI (p < 0.001). Among the 257 patients (79.3%) transported without LST, 6 (2.3%) received TCHI. When transported with LST, (86.6% vs. 7.8%; p < 0.001) patients had a NACA score of ≥ 4. Median transport duration was 14 minutes and was similar regardless of the use of LST. Mean time interval from arrival to the first TCHI was 7.7 ± 4.0 minutes with LST versus 9.3 ± 6.4 minutes without LST (p = 0.414). (Table 2)

Table 2: Patients characteristics
### Table 3: Transport mode and the need for TCHI

| Transport mode | TCHI received | Total patients |
|----------------|---------------|----------------|
|                | Yes           | No             |                |
| LST            | 40            | 27             | 67             |
| No LST         | 6             | 251            | 257            |
| Total patients | 46            | 278            | 324            |

Legend: Sensitivity: 40/46 (87.0%); specificity: 251/278 (90.3%); positive predictive value: 40/67 (59.7%); negative predictive value: 251/257 (97.7%).

Less than 2% of TCHI was performed when EMS providers did not use LST and did not expect TCHI to be realized (NPV = 98.4%; 95%CI = 96.8–99.9). When EMS providers expected TCHI (n = 50) it was performed in 68% of cases (PPV = 68.0%, 95%CI = 55.1–80.9; NPV = 98.5%, 95%CI = 97.0–99.9; sensitivity = 89.5%, 95%CI = 80.6–98.4; specificity = 94.4%, 95%CI = 91.7–97.1; p < 0.001). LST, NACA ≥ 4 and TCHI expected by EMS providers were the most predictive variables for the need for TCHI (p < 0.001). (Table 4)
Table 4: Predictors of TCHI realization

| Variable                               | Odds ratio | 95% Confidence Interval |
|----------------------------------------|------------|-------------------------|
| LST                                    | 0.039      | 0.017 - 0.088           |
| NACA ≥ 4                               | 0.067      | 0.033 - 0.137           |
| TCHI expected by EMS providers         | 0.057      | 0.031 - 0.105           |
| Male                                   | 0.572      | 0.327 - 0.999           |
| Age below 65 years                     | 1.054      | 0.612 - 1.817           |

Legend: EMS: Emergency Medical Services; LST: lights and siren transport; NACA: National Advisory Committee for Aeronautics; TCHI: time-critical hospital intervention.

The most common TCHI within 15 minutes of hospital arrival was fast-track for patients presenting with STEMI, stroke or OHCA (n = 30), then intensive therapeutic medical procedures (n = 19), followed by invasive vascular procedures (n = 7) and, finally, respiratory support procedures (n = 5). No patient died within this interval. Fast-track patients represent 44.8% of the LST used and 75% of the TCHI performed.

When patients were transported with LST, they were hospitalized significantly more often in acute care units (ICU, IMCU) and less often in GW or discharged from the ED. (Table 5)

Table 5: Hospitalization wards from the ED (except for 13 patients transferred to regional hospitals)

|                     | Total          | LST            | No LST         |
|---------------------|----------------|----------------|----------------|
| Total, n (% of all patients) | 311 (100)      | 64 (20.6)      | 247 (79.4)     |
| ICU, n (%)          | 15 (4.8)       | 13 (20.3)      | 2 (0.8)        | <   |
| Surgery room, n (%) | 7 (2.3)        | 1 (1.6)        | 6 (2.4)        |     |
| IMCU, n (%)         | 72 (23.2)      | 31 (48.4)      | 41 (16.6)      | <   |
| GW, n (%)           | 133 (42.8)     | 10 (15.6)      | 123 (49.8)     | <   |
| Ambulatory care, n (%) | 83 (26.7)    | 9 (14.1)       | 74 (30.0)      |     |

Legend: ED: emergency department; ICU: intensive care unit; IMCU: intermediate care unit; GW: general ward.

Independently of the use of LST, the average LOS was 5 ± 7 days and the hospital mortality rate was 3.4% (n = 11).
Discussion

Non-trauma patients represent the majority of EMS cases. It is therefore important to study this specific population when addressing the appropriate use of LST. The majority of our non-trauma patients transported with LST benefitted from TCHI, as found by others for trauma patients [8]. Almost 60% of the LST patients benefitted from TCHI, and LST was significantly associated with TCHI realization. Nevertheless, when fast-track is excluded this rate drops to 27%. On the other hand, as in Ross et al.’s study [8], less than 5% of patients transported without LST required TCHI. Regarding over-triage, defined as LST patients without TCHI, our rate was significantly lower (40% vs. 77%). This suggests better clinical decision-making from EMS professionals in our system.

Significant predictors of TCHI included the use of LST, a NACA score of ≥ 4 and an EMS expectation of TCHI. The latter could be included in further research to analyze the choice of EMS transport mode.

Based on our findings, LST overuse remained non-negligible, with a PPV (LST with TCHI) of only 59.7%. This was similarly described in previous studies [8,9,12,13] and confirms the need to define evidence-based protocol for guiding EMS transport practice. Regarding those results, LST for non-trauma patients should be used almost exclusively for fast-track or when EMS providers expect TCHI, taking note of traffic and weather conditions. If these criteria were applied in this study, LST could have been reduced from 20.7% to 16.3%. Improvement of LST use requires additional education of EMS providers on TCHI if other studies are to confirm our findings.

This study is subject to several limitations. First, it is a single-centre study with short prehospital transport distances and durations, and with paramedics having a high level of autonomy. Secondly, we used a convenience sample. Only true random samples produce representative estimates for demographic variables in at least 95% of samples; random time-block or business hour samples differ systematically from the population, although in this specific data set the magnitude of the differences was not large. However, for many research projects these differences may not be clinically significant, which makes our results and discussion admissible [20]. Thirdly, given the small sample size, the precision of our results may be low.

Conclusions

In this prospective study, the use of LST was significantly associated with TCHI realization. This was principally due to fast-tracks validated from the field by hospital physicians. To reduce over-triage (LST without TCHI), LST should only be used when a fast-track is
activated or when TCHI is expected by EMS providers.

**Abbreviations**

CI, confidence interval; ECG, electrocardiogram; ECMO, extracorporeal membrane oxygenation; ED, emergency department; eFAST, extended focused assessment with sonography for trauma; EMS, Emergency Medical Services; GW, general ward; ICU, intensive care unit; IMCU, intermediate care unit; IQR, interquartile range; LOS, length of stay; LST, lights and siren transport; NACA, National Advisory Committee for Aeronautics; NPV, negative predictive value; OHCA, out-of-hospital cardiac arrest; OR, odds ratio; PPV, positive predictive value; ROSC, return of spontaneous circulation; SD, standard deviation; SPSS, Statistical Package for the Social Sciences; STEMI, ST-elevation myocardial infarction; TCHI, time-critical hospital intervention.

**Declarations**

**ETHICS APPROVAL AND CONSENT TO PARTICIPATE**
The project (project number 2016-01763–25.10.2016) was submitted to the Swiss Ethics Commission. Due to the lack of clinical data from the patients, a formal request was deemed unnecessary.

**CONSENT FOR PUBLICATION**
Not applicable.

**AVAILABILITY OF DATA AND MATERIALS**
Full collected data are available by email from the corresponding author.

**COMPETING INTERESTS**
The authors declare that they have no competing interests.

**FUNDING**
None.

**AUTHORS’ CONTRIBUTIONS**
OB and FD conceived the study process, interpreted the data and drafted the manuscripts and revisions. OB and EC participated in the acquisition of the data. OB and DM generated the statistics. MP, OH and PNC were involved in designing and reviewing the manuscripts. All authors read and approved the final manuscript.
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