Utilization of Warning Lights and Siren Based on Hospital Time-Critical Interventions

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Abbreviations:
ALS = advanced life support
ED = emergency department
EMS = emergency medical services
HI = hospital intervention
L&S = lights and siren
PI = prehospital intervention

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Abstract

Objective: The objective of this study was to evaluate the time saved by usage of lights and siren (L&S) during emergency medical transport and measure the total number of time-critical hospital interventions gained by this time difference.
Methods: A retrospective study was performed of all advanced life support (ALS) transports using lights and siren to this university emergency department during a three-week period. Consecutive times were measured for 112 transports and compared with measured transport times for a personal vehicle traveling the same day of the week and time of day without lights and siren. The time-critical hospital interventions are defined as procedures or treatments that could not be performed in the prehospital setting requiring a physician. The project assessed whether the patients received the hospital interventions within the average time saved using lights and siren transport.
Results: The average difference in time with versus without L&S was -2.62 minutes (95% CI: -2.60– -2.63, paired *t*-test $p < 0.0001$). The average transport time with L&S was 14.5 ±7.9 minutes (min) (1 standard deviation/minute (min), range = 1–36 min.). The average transport time without L&S was 17.1 ±8.3 min (range = 1–40 min). Of the 112 charts evaluated, five patients (4.5%) received time-critical hospital interventions. No patients received time-critical interventions within the time saved by utilizing lights and siren. Longer distances did not result in time saved with lights and siren.
Conclusions: Limiting lights and siren use to the patients requiring hospital interventions will decrease the risks of injury and death, while adding the benefit of time saved in these critical patients.

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Introduction

The routine use of lights and siren (L&S) by emergency medical services (EMS) personnel has been a longstanding tradition, but with evidence mounting concerning its risks, many are now questioning their utility.[1–4] Position papers, such as "Use of Warning Lights and Siren in Emergency Medical Vehicle Response and Patient Transport" from the National Association of EMS Physicians (NAEMSP), state that protocols should be in place for all uses of L&S because of the risks associated with ambulance collisions including injuries, deaths, and substantial financial costs.[5] No study, to date, has demonstrated lives saved or improvement in morbidity associated with the use of L&S. As little as 43.5 seconds saved with using L&S has been recorded.[6] Although the dangers associated with L&S repeatedly have been discussed, national standards in the US have not been implemented.

Morbidity and mortality from collisions involving emergency vehicles is a major public health hazard. This study set out to evaluate the time saved when using L&S and the number of hospital interventions (HIs) performed within the time saved. Evaluating the time-critical HIs performed immediately upon arrival to the hospital should aid in validating the use of L&S in these specific scenarios.

Prehosptial Intervention	Hospital Intervention
Medications	Medications
Combivent	tPA thrombolytics
Solumedrol	Procedural Interventions
Diltiazem	Neurosurgical evacuation
Metoprolol	Cardiac catheteriztion
Aspirin	Transvenous pacing
NTG	
Versed	
D50	
Thiamine	
Benadryl	
Morphine	
Atropine	
Epinephrine	
Albuterol	
Lasix	
IV nitro	
Calcium	
Sodium Bicarbonate	
Etomidate	
Succinylcholine	
Procedural Interventions	
Transcutaneous pacing	
Endotracheal intubation	
CPR	

Table 1—Interventions recorded during the study

Methods

Study Design and Selection of Participants

A retrospective study was performed of all advanced life support (ALS) transports utilizing L&S to a university emergency department (ED) during a three-week period. A matched control group was used consisting of using personal vehicles without lights and siren. Ninety-three percent of all patients transported during this time period had used L&S. Transport times are recorded electronically by a central medical communicator when an EMS vehicle leaves the scene and again when it arrives at the hospital. All transport times were reviewed. Based on the timed documented in the EMS chart, the transport time to the hospital was calculated. As the EMS providers wrote the chart, there was a questionnaire to confirm if the times documented were accurate. If EMS personnel subjectively felt documented times were not accurate, the chart was excluded from the study. While performing this same chart review, all of the prehospital interventions provided were abstracted.

The time of travel in the control group was recorded by two medical students and one EMS fellow traveling in their personal vehicles from the location of the 9-1-1 response to the hospital. They drove during the same day of week and time of day as did the original call. They were instructed to obey all traffic laws and speed limits. All time was recorded in minutes. Any significant time delay due to weather patterns was noted and excluded from analysis.

Furthermore, medical charts were evaluated for interventions performed in the prehospital setting and upon arrival to the hospital. The interventions were divided into two groups: (1) time-critical HIs; and (2) prehospital interventions (PIs). The HIs procedures were defined as those procedures or medications that only can be performed or administered in the hospital. The PIs were defined as interventions that can be initiated by paramedics in the prehospital setting. Therefore, if the patient required a time-critical HI, the use of L&S transport could present substantial benefit. Because the interventions provided by paramedics differ depending on the region, each specific EMS system can decide which interventions they deem are time-critical HI, and consider this information when transporting patients to the hospital. Examples of time-critical HIs are in Table 1.

Setting

This study was performed using a two-tiered EMS system that is comprised of six ALS units based at a university Level-I trauma center. The mean amount of experience for the 232 paramedic providers was 6.48 years.

The emergency department treats approximately 82,000 patients per year. The emergency department is a tertiary care center for multiple specialties. Only Board Certified or Board Eligible Emergency Physicians evaluated and treated the patients.

The county population of approximately 800,000 residents is made up of 68.4% Caucasian, 13.9% Asian, 13.6% Hispanic, and 9.1% African-American residents. The county occupies 323 square miles with a combination of urban cities and suburban communities. The EMS system covers 85% of the county 9-1-1 responses.

The EMS system is comprised of a combination of paid, volunteer basic life support (BLS) units and paid, hospital-based ALS units that are staffed with two paramedics per unit. Regionally based units are dispersed based on population census and call volume. There are eight BLS units and six ALS units that respond to approximately 30,000 dispatches per year, 6,500 (22%) of these are treated by ALS personnel.

The EMS system contains 90 paramedics, 140 basic emergency medical technicians, one full-time medical director, and two EMS Fellows. The system provides 100% on-line medical direction with standing orders. Supervisors respond on all "critical calls" as defined by the medical communicator.

The medical communication center directly answers 9-1-1 calls in the city and receives requests for ALS units from police of neighboring towns. A vast majority of these requests do not provide sufficient information for call prioritization. Therefore, even with recent reports on successful medical priority dispatch system protocols limiting the use of L&S,[7] this system would not be able to implement these protocols given the insufficient information. Consequently, all of the ALS units are dispatched using L&S. Once the patient has been evaluated, the EMS system has no policy to guide L&S use.

Chief Complaint/Nature of call n (%)	
Cardiac	37 (31.9)
Cardiac arrest	2 (1.7)
Unresponsive/Unconscious	9 (7.8)
Respiratory	22 (19.0)
Trauma	11 (9.5)
Altered LOC/Signs and CVA	21 (18.1)
Gastrointestinal	4 (3.4)
Syncope	5 (4.3)
Burns	2 (1.7)
Overdose	2 (1.7)
Seizure	1 (0.9)

Table 2—Patient chief complaints (LOC = loss of consciousnesss

Data Collection, Processing, and Outcome Measures
Patient data and interventions performed were abstracted by a medical student and an EMS fellow trained in the use of Microsoft Access, Sunrise Clinical Manager (SCM), and the Emergency Department Information Management (EDIM) database. Patient care reports (PCR) were completed using laptop computers by the treating paramedic and reviewed by the EMS Fellow. The data reviewed included: (1) chief complaint; (2) transport times; and (3) interventions. The patient baseline characteristics are illustrated in Table 2. Emergency department mortality, ED discharges, ICU admissions, length of stay, and need for assisted or mechanical ventilations were documented among patients who received time-critical HIs.

Primary Data Processing
Since the times of arrival are paired by route (with and without L&S), analyses such as paired *t*-tests and confidence intervals were conducted focusing on the differences between times with L&S and times without L&S. A 95% confidence interval was created to estimate the average difference in times. To address whether the time required to arrive at the hospital depends on overall distance from the scene of the 9-1-1 call to the hospital, standard linear regression estimated the effect of time without L&S on the difference between times with and without L&S. Sensitivity analyses using robust regression were conducted in order to examine the impact of eliminating any undue influence from outliers.[8] Robust regression was broken down into a weighted regression problem in which observations with large residuals were down-weighted and estimation was conducted using an iterated least-squares procedure. Specifically, Huber regression weights, with varying tuning constants (between 1.0 and 1.7 with SAS's default as 1.345; results are reported for the default value) were considered. The SAS software (SAS system for Windows, version 9.1.3; SAS Institute Inc, Cary, North Carolina) was used for all statistical procedures.[9]

Results
During the study period, a total of 157 ALS transports using L&S were reviewed. Thirty-three transports were excluded secondary to partial L&S use, when L&S were not used during the entire transport. Twelve transports were excluded due to inaccurate times recorded by the medical communication center. A total of 112 charts were used in this analysis. The average difference in time with versus without L&S was -2.62 minutes (95% CI = -2.60– -2.63 minutes (min), paired *t*-test *p*-value <0.0001; signed rank *p*-value <0.0001) such that patient transport with no L&S took on average of 2.62 minutes longer than when using L&S. Using robust estimation, an intercept only model with Huber regression, the average difference between the time with and without L&S is -2.35 minutes (95% CI = -1.74– -2.96 min; *p*-value <0.0001). A scatter plot of the data is in Figure 1, which includes a line representing equality between the two times. The average transport time in minutes with L&S is 14.5 ±7.9 min (1SD) (range = 1–36 min). The average transport time without L&S is 17.1± 8.3 min (range = 1–40 min). The time difference ranged from 24 min faster with L&S to 16 min slower with L&S.

These findings suggest that differences in transport times are not affected by distance. Specifically, standard linear regression estimates that the difference in times increases by 1.26 minutes (95% CI = 1.24–1.28 min) for every additional 10 minutes in transport with L&S; however, scatter plot suggests these finding may be due to outliers. Huber regression estimates no significant effect of time with L&S on the difference between the two mean transport times, with an increase of 0.02 minutes (95% CI = -0.06–0.10) in the difference due to a 10-minute addition in transport time with L&S. This finding is contrary to the expectation of L&S being even more useful for longer distances.

The complete logs of interventions provided to the study patients were evaluated. Of the 112 patients transported with L&S, 108 (96.4%) were treated with PIs only. Five (4.5%) patients transported with L&S also received time-critical HI. A comprehensive record of the interventions administered during this study is listed in Table 2. In the HI group, two patients were diagnosed with ST-segment elevation myocardial infarctions (STEMI), and were taken directly to the cardiac catheterization laboratory, another received fibrinolytics for an ischemic stroke, and a fourth patient was taken by neurosurgery for an evacuation of an epidural hematoma. This patient required endotracheal intubation. The last patient was diagnosed with an unstable, third-degree heart block and required immediate transvenous pacemaker placement secondary to ineffective capture with a transcutaneous pacemaker. No HI was administered within the first 2.62 minutes of arrival. All five patients were admitted to a critical care unit and the average length of stay in the hospital was 10 days. No deaths occurred in the group who received HI.

Discussion
This is the first study to investigate the use of warning L&S by evaluating time-critical hospital interventions and examine their outcomes. The results of this study can guide EMS systems to create protocols for utilizing warning L&S based on the need for an intervention provided by personnel within the hospital only.

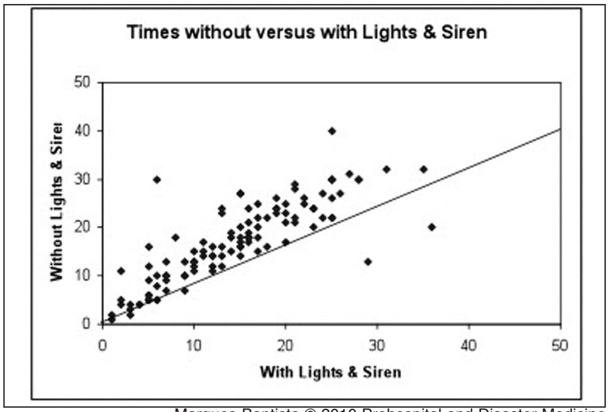

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Figure 1—Scatter plot of times without versus with lights and siren

The routine use of L&S is a ritual custom of EMS providers and is not based on evidence demonstrated to improve patient outcomes. Data are mounting that this modality has a limited capacity as a warning device.[1–7,10–13] Their use is founded on the concept of saving time, when in fact the clinical significance of the time saved is questionable. The decision to drive with L&S is largely determined by the prehospital provider. Position papers such as "Use of Warning Lights and Siren in Emergency Medical Vehicle Response and Patient Transport from the National Association of EMS Physicians (NAEMSP)" recommend that protocols be in place to minimize the use of L&S except for the few circumstances in which patient benefits outweigh the public safety risk.[5]

There are many reports of ambulance crashes when using warning L&S suggesting a major threat to both the public and emergency personnel. Roughly 70% of fatal ambulance crashes occur during utilization of warning L&S.[14] The siren is a dangerously inadequate warning device, effective only at short ranges and low speeds.[15] The injuries and fatalities reported in many states echo the dangers associated with utilizing L&S.[16–18] In a four year period in New York state, there were six fatalities and 1,894 injuries reported.[16] In a 27-month period in San Francisco, there were a reported 135 collisions injuring 20 people.[18] These numbers do not include the injuries and collisions caused by the "wake effect" of ambulances, which is estimated to be four times the collisions of EMS vehicles.[2] Monetary losses from ambulance crashes have created a problem for ensuring coverage.

In a similar fashion, Kupas *et al* created a medical protocol to limit L&S transport. They decreased the utilization of L&S and found no adverse outcomes in the non-L&S transport group.[19] In order to validate a protocol using the need for HI to guide the use of L&S, this protocol must be tested.

It is proposed that the use of warning L&S transport be limited to instances in which HIs are required. While no patients received HIs during the mean time difference saved by using L&S, 4.5% of patients had HIs beyond this time period. All patients receiving HI were triaged as emergent and seen on arrival to the hospital. The mortality rate in the HI group was 0%. This suggests the time saved by using L&S is not significant in the PI group but is important in the group waiting for a HI.

Limitations

There are a number of limitations to this study, the largest being that it is retrospective, The control and experimental responses could not be performed simultaneously. However, this weakness provided the benefit of having the paramedics unaware of the study, thus eliminating a Hawthorne effect. If paramedics were mindful of the study, they might be more likely to analyze their use of L&S and possibly even reduce L&S utilization. By performing repeat responses on the same day of the week and at the same time of the day, the study was designed to expose the control group to the same traffic configurations as encountered during the original L&S response. Theoretical weaknesses in this design are differences in weather and also changes in traffic patterns from holidays. There might have been arbitrary road closures or traffic jams, which may not have been present in both groups; with and without L&S. Also, there could have been variation in routes taken. Because the region is composed of multiple clusters of populated areas connected by major highways, most traffic is driven using the major roadways. There are not many possible routes to go from one point of interest to another and therefore, it seems that these differences would not drastically alter the arrival times.

The major roadway connecting the university hospital with neighboring towns was frequently under construction. Although this factor could account for prolonged times in the lights and sirens group, it also could have equally affected the control group. Also, only ALS transports were evaluated. It is probable that BLS and ALS units would exhibit the same mean time differences; however, this was not evaluated. Some individual paramedics may be driving faster than others; since individual drivers were not evaluated, this information was not available. In addition, this was a single EMS system study. It is possible that these results could be different with a larger sample size or if it encompassed several EMS systems.

This study only included a control group for the transport portion when evaluating the differences in arrival times. The control group did not transport patients, and therefore, no comment can be made on differences in clinical outcomes among the two groups.

Lastly, it is possible that patients with more serious illnesses had lights and siren compared with those who were less critical. Since only 7% of patients during this time interval did not have L&S, it is unlikely that this influenced the results. Because a mentality exists in the system that L&S result in improved patient care, it is recognized that this is possibly higher percent than other systems throughout the country.

Conclusions

The average time saved with L&S was 2.62 minutes which was statistically significant, but may provide no major clinical advantage if the intervention has started in the prehospital setting. Therefore, L&S use in patients requiring only PIs is not justified. Additionally, further research is needed to decide if the use of L&S is justified in patients requiring HIs. Regional HIs should be taught to prehospital providers

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