

Association between the mode of transport and in-hospital medical complications in trauma patients: findings from a level-I trauma center in Saudi Arabia

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BACKGROUND: In Saudi Arabia, injury is the leading cause of death. Even if nonfatal, the impact of injuries on population health is enormous, as thousands of young patients suffer permanent disabilities every year. Unlike in developed countries, private transportation (PT) is a common means to transport trauma patients. Outcome differences between patients transported via PT relative to emergency medical services (EMS) has not been previously explored.

OBJECTIVES: To evaluate the association between transportation mode and in-hospital complications among trauma patients.

DESIGN: Retrospective.

SETTING: Tertiary care center.

PATIENTS AND METHODS: The study included all patients (≥ 16 years), who were admitted following trauma.

MAIN OUTCOME MEASURES: The main outcome in the study was the occurrence of any medical complications including stroke, sepsis, myocardial infarction, pulmonary embolism, pneumonia, renal failure, acute respiratory distress syndrome, and cardiac arrest.

RESULTS: The 493 patients were relatively young (over two-thirds of the sample were 45 years old or younger) and over half the population sustained injuries due traffic crashes. More than half (58%) of patients arrived via private transportation. Regression analyses revealed that in-hospital complications following injuries were significantly lower among those who arrived via PT. However, after incorporating propensity score matching, we found no difference in hospital complications (OR=0.55, 95% CI 0.25-1.17).

CONCLUSION: Multiple factors may influence this unexpected finding, such as distance to health care settings, the belief that PT is faster or lack of knowledge of the EMS contact number. Further efforts are needed to raise awareness of the importance of using EMS to transport trauma patients to hospitals. Prevention programs to reduce traffic crashes may facilitate reduction in traumatic injuries and associated complications.

LIMITATIONS: Retrospective and conducted in one center only.

Trauma is among the ten leading causes of death worldwide, accounting for 9% of deaths.¹ Even if nonfatal, it is also a growing cause of preventable disability and is expected to be more prevalent than communicable diseases by 2020.² Saudi Arabia

has struggled with traumatic injuries for decades.³ Traumatic injuries are the leading cause of death nationwide, accounting for about a fifth of all deaths.⁴ These injuries have an enormous impact on health as 31% of the population are younger than 19 years

old.⁵ According to the report of the Global Burden of Disease, 22.6% of years of potential life lost in the country is due to traumatic injuries.⁶ Furthermore, Saudi Arabia has one of the highest motor vehicle collision (MVC) death rates with an estimated 27 deaths per 100 000.⁷ Adding to this burden, MVCs account for 83% of all hospital trauma-related admissions.⁸ Clearly, trauma represents a major threat to health and prosperity in this developing country.⁹

Injuries can lead to long-standing health consequences and impaired health-related quality of life.¹⁰ Numerous factors may influence health outcomes of injuries including injury mechanism, injury severity, transportation mode and pre-hospital time.¹¹ In developed countries, severely injured patients are mostly transported by emergency medical services (EMS), while in developing countries private transportation (PT) may be more popular due to the lack of EMS services.¹² It is unknown how often patients use EMS services in Saudi Arabia following trauma and whether it is associated with improved outcomes. EMS is provided by the Saudi Red Crescent Authority (SRCA), which was established around 85 years ago. SRCA serves all individuals living in Saudi Arabia free of charge and regardless of their insurance coverage. Nowadays, the SRCA has 78 centers dedicated to serving the Riyadh region. Approximately, 30% of all SRCA are trauma related.¹³

Trauma is a time sensitive condition. For severe cases, patients may experience a reduction in chance of survival as the delay in treatment increases.¹⁴ Therefore, early and fast transport is a vital step. However, patients are not always transported in a timely manner using PT or EMS. Which mode is faster remains controversial. In Zambia, 95% of the patients who presented in the first hour arrived using private or public transportation while EMS averaged 10.9 hours.¹⁵ While a study from the US showed less difference with mean time with PT averaging 26 minutes and 30 minutes for EMS.¹⁶ Less discrepancy was also observed in Germany (median time EMS=59 minutes vs. PT=46 minutes).

Published reports suggest EMS is associated with improved outcomes because of early on-scene stabilization before transport and less treatment time due to early announcement.¹² However, some studies found trauma patients, transported by EMS, at higher risk of mortality than those who arrived via PT.¹⁷ On the other hand, a study in Oman examined trauma patients that were transported by EMS and found no significant differences in in-hospital mortality and secondary health outcomes compared to trauma patients who were transported using PT.¹⁸

PT is likely faster, but there is a delay in pre-arrival

announcement, which is needed to allocate resources. This in turn could eventually contribute to slowing the in-hospital workflow and impact health outcomes.^{12,15,16} Moreover, fast transportation without specialized care of trauma patients may have adverse effects on the health outcomes because family members, friends or bystanders have no medical training to stabilize the patient's condition.¹⁹ Therefore, a pre-hospital trauma care system is believed to reduce mortality and morbidity.¹⁰

To our knowledge, there is no literature that describes the frequency of PT and that has evaluated the influence of mode of transportation on clinical outcomes in Saudi Arabia. Our study assessed the association between transportation mode and differences in health outcomes among trauma patients treated in a trauma center in Riyadh. We hypothesize that patients transported by EMS receive early stabilization, earlier assessment and treatment at the hospital due to early announcement of arrival and therefore have better health outcomes.

PATIENTS AND METHODS

This study was conducted at King Abdulaziz Medical City (KAMC) in Riyadh. KAMC is one of the largest hospitals in the country with a capacity of over 1000 beds. The hospital meets the criteria of a level-I trauma center.²⁰ The hospital receives over 200 000 emergency department (ED) visits annually, and about 46% of total hospital admissions are through the ED.²⁰

This retrospective study was conducted at KAMC between January and June of 2016. Patients 16 years old or older were identified through KAMC's trauma registry. The registry has been established since 2001 and collects information about all trauma patients who were admitted to KAMC or died due to traumatic injury. For the present study, patients who died on the scene were excluded. The study sample included 493 trauma patients. Pediatric patients were not included in the trauma registry as they are treated in King Abdullah Specialist Children Hospital.

The trauma registry includes numerous variables such as type of injury, mechanism of injury, type of transportation, diagnosis, procedure, surgery, Injury Severity Score (ISS),²¹ and Revised Trauma Score (RTS).²² The main independent variable was transportation mode, which was classified into EMS (ground ambulance or helicopter) and private transportation (friends, relatives, bystanders, or police).

Unfortunately, outcome variables were not collected as part of the trauma registry. Therefore, three research coordinators were trained to review medical records and ascertain health outcomes. The main outcome in the study was the occurrence of any medical

complications including stroke, sepsis, myocardial infarction, pulmonary embolism, pneumonia, renal failure, acute respiratory distress syndrome, and cardiac arrest. These complications were selected, as they have been shown to have the highest attributable mortality in trauma patients.²³

All analyses were performed using STATA 14 for Mac (STATA Corp., College Station, TX). Complications were used as a binary variable (yes. vs. no) based on the occurrence of any of the above-mentioned conditions. Descriptive statistics of patients, by complication status, for categorical variables were compared using chi-square tests and t test for continuous variables. A significance level of $P < .05$ was declared as statistically significant.

The association between transport type and in-hospital complications was evaluated using a multivariable logistic regression. PT was treated as a binary variable (EMS transport as the reference). The model was adjusted for age (continuous), gender (binary: female as reference), ISS (continuous), RTS (continuous), Glasgow coma scale (continuous), hypotension (binary), surgery (binary), and mechanism of injury (binary: MVC vs. other). MVC included drivers, occupants, pedestrians and those injured in a motorcycle accident.

Because we hypothesized that severity might play a role in the decision of the type of transport, we also performed the analysis incorporating propensity score matching (PSM).²⁴ This approach has become a popular method to address selection bias and has been found to reduce bias due to treatment selection.²⁵ To incorporate PSM, we first constructed a logistic regression model with transport type as the outcome. Model covariates included age, gender, ISS, RTS, surgery, hypotension, Glasgow Coma Scale (GCS), and surgery. Next, we calculated the probability of being transported via PT for each patient. This probability was then included as a continuous variable in the first model evaluating the association between transport model and in-hospital complications.

The present study was approved by the institutional review board in King Abdullah International Medical Research Center with reference number RYD-16-419812-131150. The study was funded by King Abdullah International Medical Research Center. The datasets used and/or analyzed during the current study are obtained from KAMC trauma registry and available from the corresponding author on reasonable request.

RESULTS

Of 493 trauma patients who met the inclusion criteria, over half of the patients (58%) used PT while the re-

maining used EMS. Overall, the sample was relatively young, about two thirds of patients were 45 years of age or younger (68.9%). Moreover, the sample was predominantly males (77%) and MVC caused half of the injuries (**Table 1**).

About a fifth of the study population suffered in-hospital complications (19.6%). Compared with those without complications, patients who suffered complications following trauma admission were older (mean=44.7 vs.37.2, $P < .001$) and had shorter hospital stays (mean=10.5 vs 27.0, $P < .0001$) (**Table 1**). Ninety-five percent of the patients survived, and of 24 (4.9%) who died, 18 (75%) had complications. ISS was lower in patients with no complications compared to patients who suffered complications (mean=8.5 vs. 18.6, $P < .0001$) and GCS was higher (mean=14.29 vs. 11.18, $P < .0001$). Missing values ranged between 0.2% in mode of transportation and GCS to 2.6% in hospital length of stay.

Regression analyses suggested that PT was associated with a lower likelihood of in-hospital complications following traumatic injuries than patients transported via EMS transportation (first model: OR=0.25, 95% CI=0.15-0.41). This finding remained despite adjusting for potential confounders (second model: OR 0.45, 0.22-0.94) (**Table 2**). However, no differences were observed after incorporating PSM (third model: OR=0.55, 95% CI 0.25-1.17). Patients who sustained injuries in MVC were four times more likely to die than those who sustained other injuries (third model). These mechanisms were fall injuries (30.0%), homicide (5.9%), pedestrian (4.7%) and motorcycle injuries (3.5%). The remaining 13.8% represented other injuries. While a one-year increase in age was associated with a 3% increase in hospital complications (OR=1.03, 95%CI=1.02-1.05). The other variables in the adjusted analyses showed no association (**Table 2**). The means of transport differed for some types of complication (**Table 3**).

DISCUSSION

This study found over half of the trauma patients seen at a large trauma center used PT to reach the hospital. After adjusting for the potential confounders, we found no differences between PT and EMS transportation in in-hospital complications. In the present study, 19.6% of trauma patients developed complications. This is quite striking because it is higher than what has been reported in other countries.^{26,27} For example, previous studies reported a 12.5% in-hospital complication rate among trauma patients in the United States.²⁶ The presence of a well-established EMS system would be more safe to trauma patients than PT as the leading cause of

Table 1. Descriptive characteristics by complication status.

Variable	Categories	Frequency	Complication	No complication	P value
Age category	14-25	181 (36.7)	25 (25.8)	156 (39.4)	.015
	26-45	159 (32.2)	35 (36.1)	124 (31.3)	
	46-64	70 (14.2)	12 (12.4)	58 (14.7)	
	≥65	83 (16.8)	25 (25.8)	58 (14.7)	
Age	44.7 (23.4)	37.16 (20.5)	>.001		
Gender	Male	383 (77.7)	77 (79.4)	306 (77.3)	.655
	Female	110 (22.3)	20 (20.6)	90 (22.7)	
Mode of transportation	Ambulance	221 (44.9)	69 (71.1)	152 (38.5)	>.001
	Private transport	271 (55.1)	28 (28.9)	243 (61.5)	
Death	Survived	469 (95.1)	79 (81.4)	390 (98.5)	>.001
	Died	24 (4.9)	18 (18.6)	6 (1.5)	
Surgery	Yes	59 (11.9)	23 (23.7)	36 (9.1)	>.001
	No	434 (88)	74 (76.3)	360 (90.9)	
Hypotension	Yes	27 (5.48)	13 (13.4)	14 (3.5)	>.001
	No	466 (94.5)	84 (86.6)	382 (96.5)	
Death on arrival	Yes	6 (1.22)	3 (3.09)	3 (0.8)	.06
	No	487 (98.7)	94 (96.9)	393 (99.2)	
Motor vehicle collision	Yes	245 (49.7)	45 (46.4)	200 (50.5)	.468
	Other	248 (50.3)	52 (53.6)	196 (49.5)	
Total			97	396	
Injury severity score	18.65 (16.5)	8.51 (8.1)	>.0001		
Glasgow Coma Scale	11.18 (5.1)	14.29 (2.3)	>.0001		
Hospital length of stay	27.04 (29.9)	10.46 (12.1)	>.0001		

Data are mean (standard deviation) or number (percentage).

spinal cord injuries is transport related.²⁸

The high in-hospital complication rate could be attributed to multiple factors. First, patient condition, represented by ISS or other severity measures could be a factor. If patients are more severely injured in Saudi Arabia than other countries, complication rates may also be influenced by patient conditions.³ Second, hospital quality in the present study may be lower than those from developed countries. A previous study by Alghnam et al found MVC patients treated at KAMC about twice as likely to die than patients treated in level-I centers in the US.²⁹ Finally, other unmeasured factors could influence the in-hospital complication rate. For example, pre-hospital time as discussed before may influence the patient outcome positively or negatively.^{14,30,31}

Numerous studies have investigated the association between the type of transportation and health outcomes, but have focused on mortality. The results

of these studies are controversial. One German study and several US studies showed an increased mortality rate in trauma patients transported by EMS compared to PT.^{12,16,27,32} However, a study in Oman showed no differences in mortality among injured patients transported by EMS compared to PT.¹⁸ To our knowledge the current study is the first study in Saudi Arabia that explores the influence of the type of transportation on in-hospital complications. Our initial results showed a higher level of complications in trauma patients that are transported by EMS. Contrary to our findings, it is expected that trauma patients transported by EMS develop lower complication rates than the PT group due to several reasons including better care, safer handling, and an experienced pre-hospital approach provided to trauma patients by trained EMS personnel, as well as early announcement of arrival, which improves the in-hospital process.^{12,33}

The results of the present study showed that 58% of

patients used PT. Although this is unexpectedly high, this finding concurs with a Zambian study that reported 53% of trauma patients utilized PT to reach the hospital.¹⁵ On the other hand, a couple of studies in the US and Oman reported much lower estimates of 10% to 33%, respectively.^{12,18}

Many factors could be attributed to the higher dependence on PT as a mode of transportation in Saudi Arabia. First, individuals may not be fully informed of the role and services provided by SRCA. A study by

Hamam et al investigated the public's awareness of EMS in Saudi Arabia and found that 33 percent were unaware of the telephone number.³⁴ Clearly, there is a significant need to enhance the awareness of how to contact EMS through social media and other outlets. Moreover, unlike in the US, police, fire, traffic police and EMS all have different numbers in Saudi Arabia. Therefore, a unified emergency number may help solve the problem by minimizing confusion about how to contact emergency services. Second, time delay and distance to hospitals may explain why patients were more likely to use PT. A previous study showed over half the respondents expect EMS to arrive within thirty minutes or more.³⁴ Another study by Alrazeeni et al examined nontransported EMS calls and found 65% had a 15-minute response time and 17% had up to a 30-minute response time.³⁵ Studies from other countries reported a shorter response time. A study from Iran showed most EMS calls were delivered within 8 minutes,³⁶ while in Beijing the median response time was about 16.5 minute.³⁷ Clearly, further studies are needed to evaluate response time and associated complications in Saudi Arabia among trauma patients.

Obstacles encountered by EMS providers could delay EMS and eventually contribute to high PT usage and increased non-transported EMS calls. For example, traffic congestion seemed to be a cause of delay in 76.3%.³⁸ Second, address identification is a major challenge in Saudi Arabia, unlike developed countries. According to a study of non-transported EMS patients, about 5% of the study population was not found due to the location being wrong.

The Global Positioning System (GPS) or a smartphone application to guide EMS to the location of the patients may overcome the challenge of identifying locations.³⁵ In a US study comparing two EMS teams, one with GPS navigator and the other without, found the team with GPS to be faster.³⁹ Another study compared time and outcomes before and after introducing GPS to the EMS and was associated with a reduced response time and improved survival.⁴⁰ In Saudi Arabia, the use of GPS systems to deliver food and other services is quite common. Fortunately, at the time of writing, the SRCA launched a smartphone application to help the public locate the patient accurately.³⁹ Further research is warranted to improve EMS and ultimately improve care.

Another potential explanation for the high utilization of PT is patient refusal. In Saudi Arabia, more than half of the non-transported calls were due to refusal of the patient to be transported to the hospital.³⁵ On the contrary a much lower percentage of patient refusal was

Table 2. Regression analysis of the association between transport mode and in-hospital complications as the dependent variable.

Variables	Second Model		Third Model	
	OR	95% CI	OR	95% CI
Private transportation	0.45	0.22-0.94	0.55	0.25-1.17
Age	1.03	1.01-1.04	1.03	1.02-1.05
Gender	0.96	0.47-1.95	0.88	0.43-1.81
Injury severity score	1.11	1.05-1.16	1.06	0.99-1.13
Revised trauma score	0.62	0.25-1.54	0.60	0.24-1.46
Glasgow Coma Scale	1.005	0.75-1.33	1.06	0.80-1.41
Surgery	2.32	1.02-5.27	1.99	0.85-4.63
Hypotension	2.22	0.72-6.86	2.99	0.92-9.73
Motor vehicle collision	2.47	1.18-5.18	4.45	1.62-12.2
Propensity score			0.10	0.00-1.30

Table 3. Medical in-hospital complication by type of transport.

Complication	Emergency medical service n (%)	Private transport n (%)	P value
Stroke	5 (71.4)	2 (28.6)	.156
Sepsis	19 (76.0)	6 (24.0)	.001
Myocardial infarction	2 (66.7)	1 (33.3)	.447
Pulmonary embolism	10 (66.7)	5 (33.3)	.085
Pneumonia	29 (76.3)	9 (23.7)	<.001
Renal failure	18 (69.2)	8 (30.8)	<.01
Acute respiratory distress syndrome	14 (77.8)	4 (22.2)	.004
Cardiac arrest	16 (80.0)	4 (20.0)	<.001

Data are numbers (percentage).

observed in US, ranging from 5% to 25% and 30%.⁴¹⁻⁴³ A study of refused EMS transportation found trauma to be the chief complaint of 68 percent of the study population.⁴³

Saudi Arabia endures a major burden due to MVC; it is the leading cause of death. Therefore, effective preventive programs are warranted to prevent MVC and reduce associated complications. Examples of successful prevention have been found in Saudi Arabia. For instance, a retrospective study by Alghnam et al found reductions in injury severity and mortality after the implementation of a camera ticketing system to reduce speed violations.⁴⁴ Consequently, expanding such preventive measures may reduce the burden on the health-care system and improve public health.

There are several limitations to the present study. First, the study was retrospective so some information was not documented such as the pre-hospital time, which may influence the findings. Second, this study was conducted in a single hospital. Trauma severity and pattern may be different in other hospitals and in other countries, which can impact the findings. Therefore, the

generalization of the findings to Saudi Arabia or even Riyadh or to other countries remains unclear. However, several Gulf Cooperation council countries share a similar healthcare systems and even developed countries such as Canada and the UK share some similarities to that of the emergency care system in Saudi Arabia.⁴⁵ Further research is needed to compare the findings to other countries.

In summary, we found no differences in hospital complications between patients who used PT compared with EMS following traumatic injuries. Further investigation is warranted to identify the underlying causes of complications to facilitate reduction and improve patient outcomes. Increasing awareness of the EMS contact number may increase EMS utilization. Finally, effective preventive programs to prevent MVC are desperately needed reduce associated complications and improve population health.

Conflict of interest

The authors declare that they have no competing interests.

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