Original Article

Incidence and Predictors of Adverse Events and Outcomes for Adult Critically Ill Patients Transferred by Paramedics to a Tertiary Care Medical Facility

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Abstract

Objective: The aim of this study was to determine the incidence of adverse events and patients' outcomes in inter-facility critical care transfers by paramedics.

Methods: We conducted a retrospective cohort study of adults undergoing inter-facility transfer to a tertiary medical facility by paramedics. We included all patients transferred between 1st June, 2011 and 31st December, 2014. The primary outcome is in-transit adverse event and the secondary outcome is in-hospital mortality. Multiple logistic regression models were fitted to assess predictor variables for adverse events and in-hospital mortality.

Results: The incidence of adverse events was 13.7% (31/227 patients had in-transit adverse event); the most common adverse events reported were desaturation and hypotension. A unit increase in risk score for transported patients (RSTP) significantly increased the occurrence of adverse events (adjusted odds ratio [OR]: 1.36, 95% confidence interval [CI]: 1.07–1.72 and adjusted $P = 0.01$). Compared to medical patients, cardiac patients were less likely to develop adverse events (adjusted OR: 0.117, 95% CI: 0.02–0.52 and adjusted $P < 0.01$). The in-hospital mortality was 30.4% and 30-day survival was 68.1%. For two patients whose age differed by 1 year, the older patient was more likely to die (adjusted OR: 1.03, 95% CI: 1.01–1.05 and $P < 0.01$) and a unit increase in RSTP significantly increased occurrence of in-hospital mortality (adjusted OR: 1.30, 95% CI: 1.0–1.60 and $P = 0.01$).

Conclusion: The incidence of adverse events was 13.7%. The most common observed adverse events were desaturation and hypotension. In-hospital mortality was 30.4% and 30-day survival was 68.1%.

Keywords: Allied health personnel, ambulances, critical care, patient transfer, transportation of patients

Introduction

Critically ill patients are at higher risk of developing adverse events, including mortality, following inter-hospital transfers.[1] An inter-facility transfer is defined as the transportation of patients between healthcare facilities using a licensed ambulance.[2] Inter-facility transfer is usually done by ground or air ambulance. This kind of transportation carries potential risks to a patient, especially when the patient's safety is dependent on the skills of ambulance staff as well the functionality of devices necessary for the transport.

There has been considerable debate on the ideal team composition and core skills of personnel conducting inter-facility critical transfer.[3] In particular, there is uncertainty as to whether paramedics, nurses, or doctors are the most staff

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staff suitable for this task; the efficacy of utilising a specialised transporting team remains unclear. There is little data in the literature that have evaluated the efficacy of critical care transfers by paramedics and a recent systematic review done by our research team found that there is a gap in the literature on the safety and adverse events during inter-facility critical care transfers by paramedics. We seek to investigate the incidence of adverse events in adult critical patients transported to a tertiary medical facility in Saudi Arabia by paramedics, and instances of in-hospital mortality and 30-day survival experienced by these particular patients.

Methods

Study design and setting

A retrospective cohort study of all adult patients transferred by paramedics to a tertiary medical facility was conducted. Ethical approval was obtained from the Institutional Review Board.

Emergency medical services (EMS) is a division under the Department of Emergency Medicine. In 2014, the EMS division responded to 5997 calls, of which 2143 required an advanced life support unit. Medical oversight and consultation facilities are available 24 hours, 365 days a year under an on-duty board certified emergency medicine consultant. Minimum skill competency is granted through the paramedic license requirements. All paramedics involved in inter-facility transfer of critical patients have received advanced training in operating ventilators and syringe pumps; also, they are advanced cardiac life support, basic life support, pre-hospital trauma life support and paediatric advance life support providers. However, despite the minimum skills competency which is granted through the Saudi Commission for Health Specialities which licences paramedics, there is a marked diversity in training, and there is a marked heterogeneity in the skills that individual paramedics possess.

Inter-facility transfer is usually operated with two paramedics. In the rare cases where two paramedics are not available, a registered nurse from the receiving hospital unit may support the transfer, but the paramedic is the designated primary provider of clinical care.

Paramedic protocols utilise a wide range of medications including advanced life-support medications and rapid sequence intubation medications.

Inter-facility transfer is operated with type-3 ambulance vehicles. Inter-facility transfer vehicles are equipped with portable transport ventilator, a defibrillator and monitor, at least two syringe pumps and a refrigerator to maintain opioids and intravenous fluids.

Sample size calculation

Sample size was calculated based on the incidence of adverse events. Assuming an observed incidence of 18%, the reported incidence by Domeier *et al*.,[4] 227 patients were required to achieve a margin of 5% (corresponding to 95% confidence interval (CI) of 13%–23%).

Patient selection

Four years of data (from June 1st, 2011 through December 31st, 2014) were screened and details of the first 227 critically ill adult patients, who met the inclusion criteria specified below and who were transported by paramedics, were included.

The inclusion criteria were:

- Adult patients (14 years or older are classified as adults according to the facility policies; however, for this study we define adults as 16 years or older)
- Inter-facility transferred to the facility by paramedics through land ambulance
- Risk score for transported patient (RSTP) >6.

Data collection

Patients' data were collected anonymously on-site using paper forms. The data were then transferred to a computer where they were encrypted and saved on an Excel Spreadsheet. Data were collected from referring hospitals' reports, EMS patient-care records and receiving hospital's records. Data extracted included patient demographics: the patient's age, sex, reason for transfer, length of transfer, mode of transfer and patient group (patients were divided into medical, trauma or cardiac-based on their clinical diagnosis). The following physiological parameters were collected: pulse, respiratory rate, temperature, blood pressure, oxygen saturation, Glasgow coma scale, lung sounds, skin condition, electrocardiogram results, glucose level, haemoglobin, airway devices, mechanical ventilation, ventilator setting, medication infusion, central intravenous line, chest drainage system, intracranial pressure monitoring, invasive blood pressure monitoring, blood transfusion, cardiac pacing, comorbidity, RSTP, mortality and 30-day survival.

The RSTP is a scoring system developed to identify patients at higher risk of developing complications during inter-facility transfer.[5,6] Patients with RSTP >6 were defined as critically ill patients. The complete RSTP list can be found in Appendix 1.

Method of measurements

A modified list of adverse events was adapted from the Royal College of Anaesthetists' list of critical incidents. The Royal College list itself was adopted from Dewhurst *et al*.[7] [Figure 1]. The criteria list was modified to match the Saudi ground inter-facility transfer system. Modification of the criteria included changing all air transport terms to meet ground transport processes.

The in-hospital mortality and 30-day survival were measured by accessing the hospital electronic charts for each patient. When 30-day survival was unknown, the data were considered missing.

Adverse events were identified by reviewing patient records before, during and post-transfer. Any intervention that was not initiated by the referring facility was considered a new intervention. Receiving facility records, including receiving hospital unit records, were screened to identify undocumented

Cardiovascular:
Cardiac arrest
Cardiac arrhythmia
Cardiac failure
Cardiac ischaemia/infarction
Haemorrhage
Hypertension (MAP > 120mmHg or systolic > 160)
Hypotension (MAP < 60mmHg or systolic < 80)
Other – describe
Respiratory:
Airway obstruction
Aspiration
Bronchospasm/asthma
Tracheal tube blocked or kinked
Extubation (inadvertent)
Peak airway pressures > 45cmH_2O
Hypercapnia Paco2 > 7kPa
Hypoxia Spo2 <90%
Intubation problem
Pneumothorax
Pulmonary oedema
Respiratory arrest
Ventilation difficulty/failure
Other –describe
Neurological:
Convulsion
Reduction in Glasgow coma scale by 3 points
Other – describe
Logistics:
Vehicle problem
Communication/information problem
Handover of care problem
Patient-handling problem
Other -describe
Equipment failure:
Drug/fluid delivery system problem
Equipment disconnection
Equipment failure
Equipment not available
Monitoring problem
Supply failure (gas or power)
Ventilator problem
Other – describe
Drug Related:
Wrong dose/route
Wrong drug given
Other – describe

Figure 1: List of critical incidents

events or interventions that were not documented by the transfer team.

Statistical analysis

All data collected were analysed using IBM SPSS® (IBM Corp. Released 2013, Version 22.0. Armonk, NY: IBM Corp). Continuous characteristics of patients such as age were summarised using mean and standard deviation. Categorical characteristics such as gender and diagnosis were summarised by reporting count and percentages in each category. The rate of adverse events was calculated as percentage of patients with at least one adverse event. The 95% CI for the rate of adverse events was calculated using normal approximation to the binomial distribution. Odds ratios (ORs) were used to assess if patient and transfer characteristics predict the occurrence of adverse events. Unadjusted and adjusted ORs were obtained by fitting simple and multiple logistic regression models, respectively. ORs were considered statistically different from one (no difference) if $P \leq 0.05$. Same methods were used to analyse in-hospital mortality. The only exception was that occurrence of in-transit adverse event was considered a potential predictor for in-hospital mortality.

Results

Incidence of adverse events

We identified the first 227 adult critically ill patients meeting the inclusion criteria and who were transferred by EMS paramedics. Characteristics of patients transported by paramedics are provided in Table 1.

The rate of in-transit adverse events was 13.7% (31 patients had in-transit adverse event). The most common adverse event seen in adult critical-care transport in Saudi Arabia was desaturation, and a full list of adverse events is provided in Table 2. Multiple logistic regression analysis revealed that RSTP was significantly higher in patients who developed adverse events (adjusted OR: 1.36, 95% CI: 1.07–1.72 and adjusted $P = 0.01$). A full summary of multiple logistic regression is provided in Table 3.

Table 1: Characteristics of patients transported by paramedics

Characteristic ($n=227$)	Value
Number of critical patients (%)	227 (100)
Mean age in years±SD (age range)	53±21.07 (17-108)
Sex, *n* (%)	
Male	143 (63.0)
Female	84 (37.0)
Mean length of transfer in min±SD	54.50±26.27
Mode of transfer (%)	Ground (100)
Mean RSTP±SD	9.86±3.02
Diagnosis by category (%)	
Cardiac	113 (49.8)
Trauma	58 (25.6)
Medical	56 (24.7)
Crew level (%)	Paramedic (100)
Patients on mechanical ventilation (%)	55 (24.2)
Patients with central intravenous line (%)	24 (10.6)
Patients with chest tubes (%)	4 (1.8)
Frequency of in-transit adverse event (%)	31 (13.7)
Mortality at discharge (%)	69 (30.4)

Range 0-22. Patients >6 are 'high risk'. SD: Standard deviation, RSTP: Risk score for transported patient

Table 2: List of adverse events seen by paramedics

Type of adverse event ($n=31$)	Frequency (percentage of total patients)
Desaturation (SpO_2 <90%)	10 (4.4)
Hypotension (MAP <60 mmHg or systolic <80)	7 (3.1)
Arrhythmia	5 (2.2)
Agitation***	4 (1.8)
Arrest	4 (1.8)
Convulsion	1 (0.4)

***Patients on mechanical ventilation required a bolus of sedative and/or paralytic agent. SpO_2: Peripheral capillary oxygen saturation, MAP: Mean arterial pressure

In-hospital mortality and 30-day survival

The in-hospital mortality was 30.4% of patients transferred by paramedic. The 30-day survival was 68.1% (3 patients died within 30 days post-discharge). Missing data pertained to 1 patient (this patient had been discharged to a long-term care facility). Multiple logistic regression analyses showed that patients with in-hospital mortality had a higher age (adjusted OR: 1.03, 95% CI 1.01–1.05 and adjusted $P < 0.01$) and a higher RSTP (adjusted OR: 1.30, 95% CI: 1.06–1.60 and adjusted $P < 0.01$). A full summary of the multiple regression analysis is provided in Table 4.

Limitations

One important limitation of this study is the retrospective design. The risk of unmeasured confounding variables is

Table 3: Summary of results assessing which variables predict adverse events

Variable	Unadjusted analysis	Adjusted analysis	
	OR (95% CI)	OR (95% CI)	*P*
Age (/year increment)	1.01 (0.99-1.03)	1.00 (0.97-1.02)	0.99
Sex (female)	1.27 (0.58-2.74)	1.11 (0.46-2.81)	0.77
Medical	Reference	Reference	
Trauma	0.82 (0.33-2.02)	0.53 (0.17-1.60)	0.26
Cardiac	0.36 (0.11-1.13)	0.11 (0.02-0.52)	<0.01
RSTP	1.32 (1.17-1.49)	1.36 (1.07-1.72)	0.01
Length of transfer	1.01 (0.99-1.02)	1.00 (0.98-1.01)	0.80
Mechanical ventilation	0.16 (0.07-0.37)	0.40 (0.08-1.97)	0.27
Central IV	0.42 (0.15-1.16)	2.54 (0.65-9.86)	0.18

RSTP: Risk score for transported patient, IV: Intravenous line, CI: Confidence interval, OR: Odds ratio

Table 4: Summary of results assessing which variables predict in hospital mortality

Variable	Unadjusted analysis	Adjusted analysis	
	OR (95% CI)	OR (95% CI)	*P*
Age (/year increment)	1.02 (1.01-1.03)	1.03 (1.01-1.05)	<0.01
Sex (female)	1.24 (0.69-2.22)	0.98 (0.46-2.09)	0.97
Medical	Reference	Reference	
Trauma	1.24 (0.62-2.47)	0.86 (0.35-2.13)	0.76
Cardiac	1.01 (0.50-2.01)	0.75 (0.25-2.29)	0.62
RSTP	1.48 (1.32-1.65)	1.30 (1.06-1.60)	0.01
Length of transfer	1.02 (1.01-1.03)	1.00 (0.98-1.01)	0.83
Mechanical ventilation	0.08 (0.04-0.017)	0.32 (0.08-1.23)	0.10
Central IV	0.14 (0.06-0.36)	0.78 (0.22-2.75)	0.71
In-transit adverse event	6.47 (2.85-14.70)	2.84 (0.97-8.30)	0.06

RSTP: Risk score for transported patient, CI: Confidence interval, OR: Odds ratio, IV: Intravenous line

possible. Despite our effort to obtain data from several resources (sending hospital reports, paramedics patient care reports and receiving hospital records), the risk of recall bias and the question of accuracy in providers' documentation still exists in our study. Another limitation is the narrow outcomes measured in our study; this study reports only in-transit adverse events and hospital outcomes, while other outcomes such as morbidity and length of stay were not measured. The hospital-based EMS where the study was conducted is a diverse system with different levels of training received; also, the population represented were mainly Saudi citizens which might directly impact the external validity of our study.

Discussion

In this retrospective chart review of critically ill adult patients transferred to a tertiary hospital by paramedics, we found that adverse events occurred in 13.7% of patients. The most common adverse events reported were desaturation 4.4% (ten patients) and hypotension 3.1% (seven patients). Four patients (1.8%) had an in-transit cardiac arrest. Adverse events were more common in patients with a higher RSTP and less common in cardiac patients. The adverse event rate is consistent with a similar study done in the United States of America[4] but higher than the adverse events rate reported in Ontario, Canada (6.5%).[8]

The association of increased risk of developing an adverse event in patients with higher RSTP is consistent with previous studies on RSTP.[5,6] The small percentage of traumatic patients transferred by paramedics prevents the possibility of drawing a firm conclusion regarding the development of an adverse event in this group of patients. Cardiac patients were the majority of the transported patients in our study and they were less likely to have in-transit adverse events. The low rate of adverse events (6.5%) reported from Canada by Singh *et al*.,[8] could be attributed to the different population in the Canadian study, also our study included more adverse events compared to the Singh *et al*., study, which only included new in-transit haemodynamic instability, new in-transit respiratory instability, in-transit death or in-transit major resuscitative procedure.

Four of our patients (<2%) developed in-transit cardiac arrests. The rate of cardiac arrest and death is comparable to rates in other studies.[9-11] These four patients were initially transported to our tertiary care facility because they had a cardiac arrest (in the previous 60 min of transfer) and they were revived successfully, but these patients were transferred urgently in critical conditions (low blood pressure, low heart rate, decreased level of consciousness and respiratory rate). Paramedics transferring critically-ill patients in Saudi Arabia had a noticeably high frequency of switching mechanically ventilated patients to ventilation by bag valve mask (BVM), when desaturation occurred, which required further analysis to investigate these actions. It is hard to conclude that such acts affected the patients' outcomes. In many cases, paramedics intervened in the patient's clinical status before it reached the threshold at which it could be considered an adverse event. For example, a paramedic in one of the cases switched to BVM when the patient's SpO_2 dropped to 93% and rapidly restored the level to 99%. Furthermore, it is important to notice that the existence of mechanical ventilation (in our multiple logistic regression) did not correlate with increased patient's risk of developing an adverse event ($P = 0.26$).

Patients transferred by paramedics had an in-hospital mortality of 30.4% and 30-day survival was 68.1%. The rate of in-hospital mortality is consistent with both local and internationally published data.[9,12,13]

It is planned to conduct an international expert survey to examine consensuses on the safety of paramedic intervention to adverse events. Adverse events are not always preventable. The question that remains is whether the adverse events in this study were preventable or not. The usual way to determine preventability is by means of chart (case note) review.[14-16] We planned a study of expert, implicit, review of the case note where each case would be reviewed by four

independent reviewers. The use of these many reviewers would mitigate the human low reliability of implicit case note review.[14,17]

Conclusion

In conclusion, the rate of adverse events in adult critical patients transferred by paramedics to a tertiary care facility in Saudi Arabia is 13.7%. The most common adverse events reported were hypoxia and hypotension. The in-hospital mortality was 30.4% and 30-day survival was 68.1%. Further analysis to interventions and the root cause of adverse events are recommended. The ability of paramedics in intervening safely with patients' adverse events should be investigated to ensure that paramedics mode of transferring inter-facility adult critical patients is safe.

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Conflicts of interest

There are no conflicts of interest.

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Appendix 1: Risk Score for Transported Patients (RSTP)

Risk score for transport patients*	
Hemodynamics	
Stable	0
Moderately stable (requires volume <15 ml/min in adults)	1
Unstable (requires volume >15 ml/min or inotropics or blood)	2
Arrhythmias (existing or probable)	
No	0
Yes, not serious (and AMI after 48 hours)	1
Serious (and AMI in the first 48 hours)	2
ECG monitoring	
No	0
Yes (desirable)	1
Yes (essential)	2
Intravenous line	
No	0
Yes	1
Pulmonary artery catheter	2
Provisional pacemaker	
No	0
Yes (not invasive). AMI in the first 48 hours	1
Yes (endocavity)	2
Respiration	
Respiratory rate between 10 and 14 breaths/min in adults	0
Respiratory rate between 15-35 breaths/min in adults	1
Apnoea <10 or >36 or irregular breathing	2
Airway	
No	0
Yes (Guedel tube)	1
Yes (intubation or tracheostomy)	2
Respiratory support	
No	0
Yes (oxygen therapy)	1
Yes (mechanical ventilation)	2
Assessment	
GCS = 15	0
GCS 8-14	1
GCS <8 and/or neurological disorder	2
Prematurity	
Newborn ≥ 2000 g	0
Newborn between 1200 and 2000 g	1
Newborn ≤ 1200 g	2
Technopharmacological support (see medication group table)	
None	0
Group I	1
Group II	2

*Adopted from Markakis C *et al.*

Medication group table	
Group I	Inotropics
	Vasodilators
	Antiarrhythmics
	Bicarbonate
	Analgesics
	Antiepileptics
	Steroids
	Manitol 20%
	Trombolytics
	Naloxone
	Thoracic tube
	Suction
Group II	Inotropics + vasodilators
	MAST
	Infant incubator
	General anaesthetics
	Uterine relaxants