ORIGINAL ARTICLE

Adverse Events during Intrahospital Transport of Critically Ill Patients: A Multicenter, Prospective, Observational Study (I-TOUCH Study)

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Abstract

Background: Critically ill patients are frequently transported to various locations within the hospital for diagnostic and therapeutic purposes, which increases the risk of adverse events (AEs). This multicenter prospective observational study was undertaken to determine the incidence of AEs related to intrahospital transport, their severity, and their effects on patient outcomes.

Patients and methods: We included consecutive unstable critically ill patients requiring intrahospital transport, across 15 Indian tertiary care centers over 5 months (October 11, 2022–February 20, 2023). Apart from the demographics and severity of illness, data related to transport itself, such as indications and destination, incidence of AEs, their category and treatment required, and patient outcomes, were recorded in a standard form.

Results: Eight hundred and ninety-three patients were transported on 1065 occasions out of the intensive care unit (ICU). The mean (SD) acute physiology and chronic health evaluation II score of the patients was 15.38 (±7.35). One hundred and two AEs occurred, wherein cardiovascular instability was the most common occurrence (31, 30.4%). Two patients had cardiac arrest immediately after transport. Acute physiology and chronic health evaluation II [odds ratio (OR): 1.02, 95% confidence interval (CI) – 1.00–1.05, $p = 0.04$], emergent transport (OR: 5.11, 95% CI – 3.32–7.88, $p = 0.00$), and team composition (OR: 5.34, 95% CI – 1.63–17.5, $p = 0.00$) during transport were found to be independent predictors of AEs.

Conclusions: We found a high incidence of AEs during intrahospital transport of critically ill patients. These events were more common during emergent transports and when the patients were transported by doctors. Transport by itself was not related to ICU mortality. We feel that stabilization of the patients before transport and adherence to a standardized protocol may help in minimizing the AEs, thereby enhancing patient safety.

Keywords: Adverse events, Critically ill, Intrahospital transport, Patient safety.

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Highlights

- First Indian multicenter prospective study of intrahospital transport of critically ill.
- Cardiovascular instability is the most common adverse events (AEs).
- Sicker patients, emergent transport, and team composition are independent predictors of the incidence of AEs.
- We hope this study will inform safer intrahospital transport of critically ill adults.

Introduction

Intrahospital transport of unstable critically ill patients is frequently essential for diagnostic and therapeutic purposes. This increases the risk of AEs, as the critically ill patient leaves the secure intensive care unit (ICU) environment, and faces transport with potential weaknesses such as non-availability of personnel, critical equipment, and less intensive monitoring.[1] A study published in Lancet highlighted the high incidence of arrhythmias in transported patients. This was noticed due to the use of monitors capable of displaying the electrocardiogram (ECG) continuously (using a battery-operated ECG oscilloscope) for the first time. The overall

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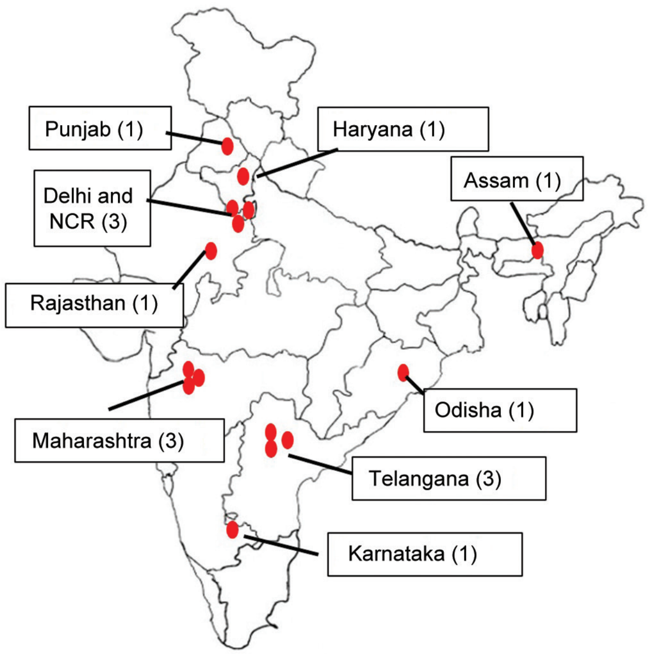

Fig. 1: Location of study centers

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incidence of arrhythmias was 79 (60 patients), of which 35 required urgent treatment.[2] Subsequent studies reported an incidence of arrhythmias ranging from 2 to 70%.[3,4] Several single-center Indian studies in adults and pediatric patients have shown a high incidence of AEs, though transport may benefit many patients, due to change in diagnosis or therapy.[5–7] There are no large multicenter studies from India looking at this aspect. We therefore decided to conduct this study to assess the frequency, risk factors for AEs, and outcomes of intrahospital transport of critically ill patients.

Patients and Methods

This prospective multicenter observational study was conducted over a period of 5 months (October 11, 2022–February 20, 2023) in 15 (13 level III and 2 level II) ICUs across India[8] (Fig. 1), after Institutional Ethics Committee approval and clinical trial registry-india (CTRI) registration (CTRI/2022/10/046354). Informed consent was obtained from a legally authorized representative, when required to do so by the respective institutional ethics committee. Eleven institutes had written protocols for transporting critically ill, while 4 did not. The primary outcome was the incidence of AEs during intrahospital transport. The secondary outcomes were a type of and predictors of AEs, and 28-day ICU mortality.

We included adult critically ill patients (18–80 years of age), categorized as “unstable.” Instability was defined variously as a need for respiratory support in the form of oxygen therapy [non invasive ventilaton (NIV) or high-flow nasal canulla (HFNC) or mechanical ventilation], or postsurgical patients with chest, abdominal drains, and head-injured patients with external ventricular drains, patients with polytrauma, cervical spine injury, coronary artery disease, or arrhythmias, and those requiring vasoactive medications. All stable or pregnant patients and those who refused consent were excluded. Patient transports from the emergency department to ICU were not excluded. The indications for transport were varied: to radiology suites for computed tomography and magnetic resonance imaging, to operation theatres (OTs) for surgeries, and to other ICUs. Some were sent to cardiac catheterization laboratories for angiography and/or interventions, to endoscopy suites for endoscopies, and also for nerve conduction and electromyography studies. The nature or category of transport was designated by the consultant intensivist looking after the patients as either emergent (undertaken immediately without time to stabilize the patients), or routine or elective (non-emergent after stabilizing the patients).

All data were entered prospectively on standardized Case Record Forms. Patient demographics (age, gender), the severity of illness scores [acute physiology and chronic health evaluation II (APACHE-II) score, and Glasgow coma score (GCS)] were recorded. Pre-transport vital parameters [systolic blood pressure, heart rate, rhythm, saturation by pulse oximeter (SpO_2), fraction of inspired oxygen (FiO_2), and SpO_2/FiO_2 ratio]. The pre-transport status of the patients and presence of devices and need for interventions such as endotracheal intubation, mechanical ventilation (invasive or noninvasive), or need for oxygen supplementation; invasive vascular devices (central venous line, arterial line, and/or surgical drains); and use of medications such as sedatives, analgesics, or paralyzing agents and vasoactive drug infusions before patients were transported, were noted.

During the transport, the following variables were noted: the transport team leader (consultant/senior registrar/nurse). Time or shift during which transported: morning (8 a.m. to 2 p.m.), evening (2–8 p.m.), and night (8 p.m. to 8 a.m.), whether the transport was emergent or elective, and the type and incidence of AEs.

The AEs were classified as equipment-related, system related, that is, cardiac, respiratory, and neurological, and whether there was an element of human error. Those who did not fit these categories were classified as others. After return to ICU, patients' post-transport condition, vital signs [Systolic blood pressure (SBP) and heart rate (HR)], GCS, change in infusion rates of medication, and patient outcomes (survival or death) within and after 24 hours, were recorded.

Statistical Analysis

The sample size was determined by the following formula:

$$n = Z^2P - (1 - P)/d^2$$

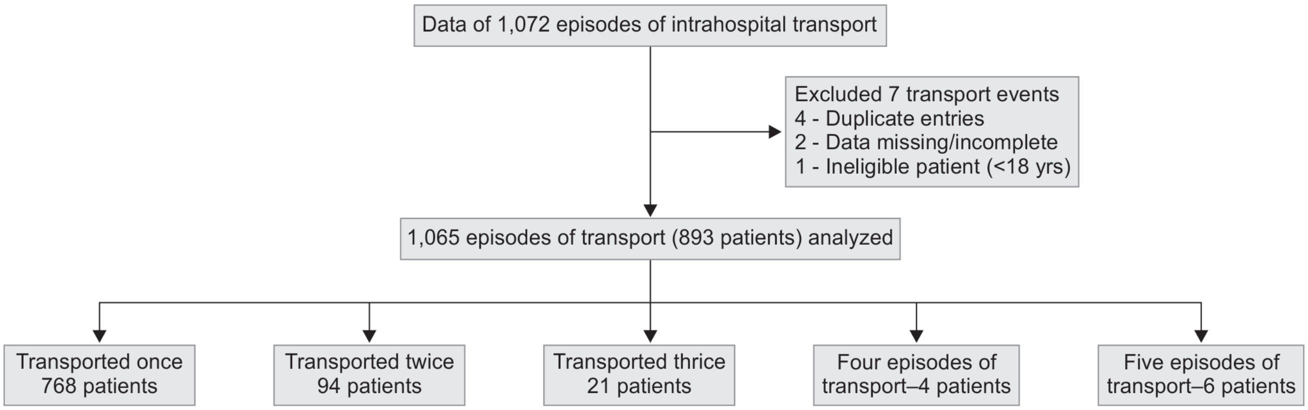

Fig. 2: Patient flow in the I-TOUCH study

where n is the sample size, Z is the statistic corresponding to the level of confidence, P is expected prevalence, and d is precision.[9] We took the proportion (p) to be = 36% from a previously published study.[10]

The estimated target sample size was 731. We presumed a 25% data loss due to dropouts, withdrawal of consent, data capture failure, etc., and therefore decided to collect data for at least 1000 patients. Data were entered in Microsoft Excel spreadsheet Version 2023. Categorical variables were expressed by frequency and percentage. Quantitative data variables are expressed as mean (± standard deviation) or median [interquartile (25th–75th) range]. Continuous and categorical variables were analyzed using Mann–Whitney U test and Chi-square tests, respectively (a p-value < 0.05 was considered significant). An online statistics calculator (social science statistics) was used to analyze the data.[11]

Results

In this prospective, multi-center observational study, we collected data of 1072 episodes of transport for 893 patients, from 15 centers over 5 months (Fig. 2). Seven instances of transport were excluded due to various issues. Of the 893 patients, 65% were male and the mean (±SD) age of the patients was 54.75 (±16.3) years. The mean (±SD) APACHE II score was 15.38 (±7.35), and the median GCS was 12 (range 7–15).

Table 1 shows the vital parameters of the patients before transport and during transport. Table 2 shows the number of patients with vascular access devices, drains, artificial airways, and ventilator status, along with the use of sedative and analgesic drugs. Only 24% of patients were given a muscle relaxant. Noradrenaline (10.9%) was the most commonly used vasoactive medication, in 40% of patients who needed vasoactive infusions.

The commonest (71.3%) indication for transport was imaging for diagnostic purposes. Two hundred fifty-five (23.9%) patients were transported to operating theaters. The remaining 52 patients (4.8%) were sent for coronary angiography (35), upper gastrointestinal endoscopy (12), EMG (1), and to other ICUs (4).

AEs occurred during 102 (9.6%) transports: commonest being cardiac (31) followed closely by airway and/or respiratory (18), and neurological (17) events. Two patients suffered cardiac arrests during transport. Equipment malfunction (13) and communication failure (2) were other types of AEs. More than one type of AEs occurred during a single transport (21) during a few transports (Fig. 3). Most patients were transported by teams led by senior registrars (669, 62.8%), and the remaining by junior consultants (291, 27.32%), and nurses (105, 9.85%). Patients who were intubated were transported by doctors. Details of these AEs are listed in Table 3.

Table 1: Vital parameters before transport ($n = 1065$)

Vital parameters	*N (%)*
SBP (mm Hg)126 [110–140]	
>180	26 (2.4)
151–179	118 (11)
90–150	895 (84)
81–89	14 (1.3)
<80	12 (1.1)
Heart rate (BPM): 89 [range 75–104]	
>150	5 (0.5)
101–150	303 (28.5)
61–100	701 (65.8)
≤60	42 (3.9)
Arrhythmia: 14 (1.3%)	
Atrial fibrillation	12 (1.1)
Ventricular arrhythmias	2 (0.2)
SpO_2: 98 [range 95–99]	
SpO_2/FiO_2	
≤100	153 (14.4)
101–250	436 (40.9)
251–399	190 (17.8)
≥400	286 (26.9)

Most of the patients (960, 90.1%) were transported by teams led by doctors which included senior registrars (669, 62.8%) or junior consultants (291, 27.32%), probably reflecting unblinded nature of the study. The doctors probably observed patients more keenly and also reported the complications more vigilantly, a possible Hawthorne effect.

We performed a univariate analysis of the presumed risk factors for possible effects on the likelihood of AEs: APACHE II score, number of transports per patient, intubated vs non-intubated, ventilated or not ventilated, need for vasopressors, emergent vs elective transport, team composition, and finally shift timing (night vs the 2-day shifts) (Table 4). On univariate analysis,

Table 2: Airway, lines, ventilation, and drugs during transport ($n = 1,065$)

Type of intervention	*No. of patients (%)*
Artificial airway	
Intubated	598 (46.9)
Mechanical ventilation	
Invasive	500 (46.9)*
Non-invasive	12 (1.1)
O_2 supplement devices	345 (32.3)
Vascular access	
Central venous access	517 (48.5)
Peripheral venous access	548 (51.4)
Arterial cannulation	441 (41.4)
Surgical drains	236 (22.1)
Vasoactive drugs	
Noradrenaline	117 (10.9)
Other vasoactive drugs	310 (29.1)
Sedatives, analgesics, and/or muscle relaxants	
Fentanyl	118 (11.07)
Propofol	159 (14.9)
Midazolam	15 (1.4)
No sedation or analgesia	164 (15.4)
Sedation–analgesia only	360 (33.8)
Sedated and paralyzed (relaxants used, cisatracurium and vecuronium)	249 (23.3)

*Ninety-eight remaining patients were on T-piece, these were intubated for airway protection

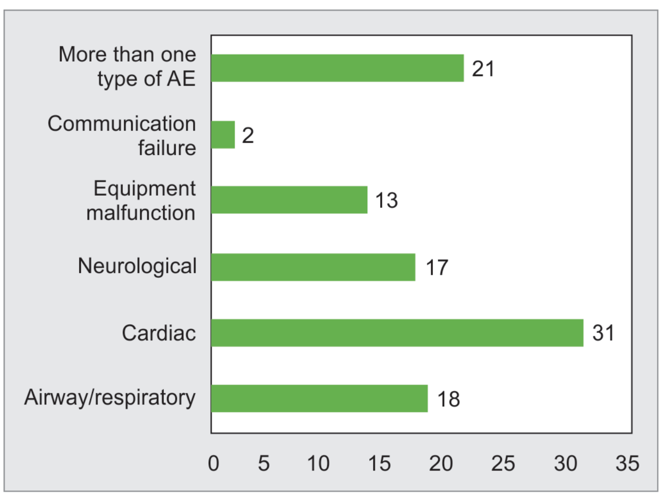

Fig. 3: Type and number of adverse events

APACHE II score, vasoactive drug infusions, emergency transport, and team composition were found to be significant risk factors for the occurrence of AEs. On multivariate analysis, however, only APACHE score [odds ratio (OR): 1.02, 95% confidence (CI) 1.00–1.05, $p = 0.04$), emergency transport (OR: 5.11, 95% CI – 3.32–7.88, $p = 0.000$) and team composition (OR: 5.34, 95% CI – 1.63–17.5, $p = 0.05$) remained significant.

When we looked at the occurrence of AEs and mortality within 24 hours or later, we found that a higher number of patients died within 24 hours, who had AEs during transport (1.9% vs 0.3%, $p = 0.02$). The 28-day ICU mortality was 91 (10.2%).

Table 3: Details of adverse events

Class of event	*Details*	*N*
Cardiovascular events (31, 30.3%)	Hypotension (SBP < 90 mm Hg)	10
	Hypertension (SBP > 180 mm Hg)	8
	Tachycardia (HR > 150 bpm)	6
	Arrhythmias (atrial/ventricular)	5
	Cardiac arrest	2
Respiratory (18, 17.6%)	Sudden desaturation to 91%	2
	$SpO_2 < 88\%$	8
	Tachypnea (RR > 30/min)	6
	Pulmonary aspiration	1
	Persistent hypoxia (persisted beyond transport)	1
Neurological (17, 16.6%)	Agitation (4)	4
	Restlessness, anxiety on (RASS scale) (7)	7
	Seizure (2)	2
	Drop in GCS (3)	3
	Hypoglycemia	1
Equipment/ logistics-related adverse events (13, 12.7%)	Nonfunctioning transport monitor	2
	Blood pressure cuff nonworking	3
	Pulse oximeter disconnection	3
	Drop in O_2 pressure in the cylinder	3
	Lift not working	2
Human error/ communication failure (2)	Transport to the wrong location	2
More than 1 adverse event in a single episode		21

RASS, Richmond agitation sedation scale

Discussion

Transport of critically ill patients out of the safe environment of the ICU is hazardous. In our study, 10% of patients had AEs, while in the literature the incidence varies from 3 to 75%.[12–14] Papson et al. described complications during intrahospital transport in 339 patients over 18 months: 230 patients suffered (67.9%) 604 AEs, with a median of 1.0 (range, 0–16) event/transport.[4] Wallen et al. studied AEs during intrahospital transport of pediatric patients.[15] In the first phase (4 months, 139 patients, 180 transports), they observed the incidence of AEs, need for interventions and factors predicting both. In the second phase, they tested the hypothesis that AEs can be attributed to the transport process itself. In the first phase, a significant adverse physiological event occurred in 71.7% and equipment-related problems in another 10% of patients. The need for major intervention was higher in ventilated (34.4%) than in non-ventilated patients (9.5%). In phase II (85 patients, 89 transports, 1 year), and at least one each of the following occurred-physiologic deterioration (64 ± 7%), major intervention (13.4 ± 5%), and equipment-related mishap

Table 4: Univariate and multivariate analysis for risk factors for adverse events during transport

Variable	*Univariate analysis OR (95% CI)*	*p-value*	*Multivariate analysis OR (95% CI)*	*p-value*
APACHE score	1.03 (1.00–1.05)	0.01	1.02 (1.00–1.05)	0.04*
Age (years)	1.00 (0.99–1.00)	0.67	–	
Gender	0.74 (0.48–1.17)	0.20	–	
Transported more than once	0.92 (0.58–1.47)	0.73	–	
Airway (intubated)	1.02 (0.68–1.59)	0.91	–	
Team composition	3.90 (1.21–12.55)	0.02	5.34 (1.63–17.5)	0.005*
Vasoactive drugs	1.53 (1–2.34)	0.04*	1.27 (0.82–1.96)	0.27
Emergency transport	4.79 (3.13–7.32)	0.00001*	5.11 (3.32–7.88)	0.000*
Night time transport	0.89 (0.52–1.52)	0.66	–	

APACHE, acute physiology and chronic health evaluation, p-value < 0.05* was considered significant

Table 5: Independent predictors of intensive care unit mortality in transported patients

Variable	*Multivariate analysis OR (95% CI)*	*p-value*
APACHE II score	0.90 (0.87–0.92)	0.000*
Vasopressor support	4.39 (2.75–7.02)	0.000*

APACHE, acute physiology and chronic health evaluation, p-value < 0.05* was considered significant

(19 ± 5%). In both phases, a need for major intervention correlated with pre-transport Therapeutic Intervention Severity Score, and duration of transport.

Several single-center Indian studies have reported a high incidence of serious AEs such as hypoxia and hypotension, and the need for interventions such as cardio pulmonary resuscitation(CPR), endotracheal intubation.[5–7] These studies, however, also report the benefit due to changes in therapy following transport. Murata et al. in a meta-analysis (24 studies, 12,300 patients) reported a high (26.2%) incidence of AEs.[14] These AEs included agitation, arrhythmias, cardiac arrests, hypoxia, and so on. However, there was significant heterogeneity in the included studies.

Hemodynamic instability was the most common (31) AE in our cohort. Harish et al. described severe cardiovascular instability in 32 (of 102) instances, in the form of cardiac arrest (16.7%), severe bradycardia (3.3%), hypotension (3.3%), and tachycardia (1.6%), during emergency transport.[5] Another study described blood pressure changes >20% from baseline in 15.8% and arrhythmias in 4.31% of patients.[7]

The occurrence of cardiac arrest remains a grave concern and the incidence ranges from 0.34 to 1.6%.[4,15] We observed cardiac arrest in 2 (0.18%) patients who were on high doses of vasoactive agents and being transported emergently.

If patients require multiple transports, it is because of unresolved issues. In the study by Papson, 230 patients had 604 AEs.[4] In our cohort 125 patients required multiple transports (median 1, range 1–4), there was no association between repeated transports and AEs. Gimenez et al. found a weak correlation (correlation coefficient 0.40 (95% CI 0.21–0.56, $p < 0.0001$) between the number of transports and AEs.[16] This probably means that if patients are stable and the transport team is experienced, repeated transport may be undertaken with minimal risk.

It is likely that patients with high APACHE II scores may need high doses of vasoactive agents, making them vulnerable to a higher incidence of AEs. Oddly, on multivariate analysis, though statistically significant, the OR for higher APACHE II was 1.02 (95% CI – 1.00–1.05), very minimal increased risk (0.02), which probably reflects more vigilant monitoring and due care in sicker patients. Two previous studies have reported an association between the use of vasoactive drugs and AEs.[17,18] Parmentier-Decrucq et al. reported a higher incidence of AEs, if patients were on vasoactive medications, that is, norepinephrine [OR = 4 (1.8–8.8); $p = 0.001$) and dobutamine (OR = 2.7 (1.1–6.7); $p = 0.041$].[17] Lovell et al. also reported that most patients (73%) on inotrope infusions had AEs during transport.[18]

Transporting critically ill patients requires good coordination and communication. Zuchelo and Chiavone reported that 16 of 102 AEs in their study were related to battery failure or communication failure and suggested that these could have been avoided by better communication.[19] In the Australian Incident Monitoring Study in Intensive Care, the highest number of incidents (61%) were related to patient/staff management issues. Of these, the commonest (18 of 33) was communication/liaison problems.[20] Many AEs can be avoided with a specialized transport team.[21] In the current study 11 out of 15 participating centers (73%) had written protocols for patient transport. Of the 264 patients in whom intrahospital transport was undertaken, the incidence of AEs was 60 (22.7%) as compared with a total of 42 AEs in the remaining 759 patients ($p < 0.0001$). Intrahospital transport requires both physical and human resources, therefore one may expect that transport undertaken during the night shifts or on the weekends have a higher incidence of AEs. This may be due to added apprehension and stress in staff, and limited experience of personnel.[22] This was not so in our study, as there was no difference in AEs in different shifts. Parveez et al.,[23] in a single-center Indian study, also did not find any difference in AEs during transports on weekends vs weekdays (70% vs 64.3%, $p = 0.616$) or day shifts vs night shifts. In our cohort, of the 205 (19.2%) transports undertaken during night shifts, the incidence of AEs was low ($n = 18$). This may be a result of staff being extra vigilant, as they knew about the study. In a Chinese study, the number of patients transported during the night was low (6.1%).[24] It seems that most ICUs prefer not to transport patients during night shifts, unless in an emergency. On multivariate analysis, we found that intrahospital transport carried out for emergent indications increased the odds of AEs greatly (OR: 4.68, 95% CI: 3.05–7.17, $p = 0.000$). Harish et al. reported that patients with higher severity of illness scores [sequential organ failure assessment (SOFA) 16.3 ± 5.8 vs 10.0 ± 4.3, $p = 0.000$ and APACHE II 22.5 ± 11.0 vs 10.8 ± 6.5, $p = 0.000$] were significantly more likely to develop AEs and/or need CPR.[6] Acute physiology and chronic health evaluation II score in the current cohort was an independent predictor of AEs as well.

The patients who developed AEs during transport had significantly higher mortality within 24 hours of transport (1.9% vs 0.3%, $p = 0.02$). However, the occurrence of AEs did not seem to affect mortality after 24 hours. Gimenez et al. looked at the patients who developed AEs during transport, and its correlation with ICU and hospital mortality. There was no difference in ICU mortality in those with AEs during transport (35.0%) and without (22.4%, $p < 0.23$) or in-hospital mortality (45.0% vs 26.5%, $p < 0.07$).[16]

Waddell published one of the earliest studies on intrahospital transport of the critically ill.[25] He speculated that the physical movement of the trolley or bed itself may affect the patient's physiology due to physical stimuli, discomfort caused, and pain. He also made the astute observation that the lack of facilities and the limitations to the movements of the accompanying attendants may hamper their ability to provide continuing supportive care. Although discussing the difference in attitude while transporting patients in ambulances, he suggested that all possible care is taken to stabilize the patients and maintaining continuity of care. Everyone's outlook changes when transporting the patient just to "another corner of the hospital" leading to less-than-optimal preparation. This originates from the feeling that there is less chance of unfortunate incidents and a very temporary discontinuation of critical treatment may not cause too much harm. We therefore want to emphasize that this thinking needs to change and there should be emphasis on thorough preparation. All attempts should be made to provide "mobile" ICU-like care during intrahospital hospital transport.

The findings of our study emphasize the need to have written policies and protocols, the importance of communication between the members of the transport team and adequate preparation before the patient is transported.

Strengths of the Study

This is the first multicenter prospective observational study involving ICUs from various parts of India, looking at the AEs during intrahospital transport in unstable critically ill.

Limitations of the Study

In this study, the ICUs were of different levels, from different geographical locations, and with a heterogenous case mix. The ICU practices and team composition were also probably different. This being an unblinded study, it is difficult to deny the possibility of the transport teams being extra careful (with a possible reduction in the incidence of AEs), as the team was aware of being part of the study.

We did not collect the data on the duration of transport, that is, the time spent outside the ICU, which in some studies has been shown to affect the incidence of AEs. We also did not look at the ICU and hospital length of stay. We do not have data on the average dose of vasoactive medications the patients received during transport, which could have a bearing on the incidence of AEs and probably also patient outcomes.

Conclusions

Intrahospital transports are common among critically ill patients and pose a risk of serious AEs, especially during transport for emergent indications and for patients receiving vasoactive medications. The high incidence of cardiovascular AEs observed in this study highlights the need for vigilant monitoring and implementation of standardized transport policy across all ICUs. We feel that intrahospital transport should be undertaken when the benefits to the patients exceed the risks; and diagnostic tests or procedures are expected to alter the management.

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