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Critical events during intra-hospital transport of critically ill patients to and from intensive care unit

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Abstract:

OBJECTIVES: Intensive care unit (ICU) patients are at an increased risk of many catastrophic events during intrahospital transport (IHT) for various procedures. This study was planned to determine the incidence and types of adverse events occurring during the transport of critically ill patients in a tertiary care hospital.

METHODS: This prospective observational study was conducted in the ICU of a tertiary care hospital for 8 months after ethical clearance from the institute ethics committee. All patients transported out of the ICU during the audit period for diagnostic or therapeutic procedures were included in the study. Vitals and several study parameters were recorded before, during, and after shifting patients to and from the ICU. Various critical events were noted during transport and classified into major and minor critical events based on the presence and absence of potential consequences that lead to a change of therapy during transport.

RESULTS: One hundred and sixty patients were studied for consecutive IHT to and from the ICU. The patients were transported for imaging studies (58.1%), minor surgery (31.8%), major surgery (2.5%), and other procedures (7.5%). A total of 248 critical events were observed in 104 IHTs (65%; 95% confidence interval [95% CI]: 57.4%–72.1%). Hence, an average of 2.38 critical events occurred per IHT. There were 31 major events among the 248 critical events (12.5%; 95% CI: 8.8%–17.1%).

CONCLUSIONS: Standard guidelines about the accompanying personnel and monitoring need to be followed during IHT. Conduct of minor surgical procedures in the ICU and better bedside diagnostic procedures may be considered for the future.

Keywords:

Critical events, intensive care unit, intrahospital transport

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Introduction

Intrahospital transport (IHT) of critically ill patients is frequently required for diagnostic or therapeutic procedures that cannot be performed in the intensive care unit (ICU). During transport, patients are at an increased risk of complications or adverse events. Therefore, the decision of transporting the patients is based on the potential benefit to patients against the possibility of critical events occurring during transport.[1-4] Previous studies of IHT have reported a complication rate of 5.9%–66%.[2-4] These adverse events may be minor such as peripheral intravenous line displacement or nasogastric tube displacement to major like cardiac arrest or death. Smith *et al.*[3] found that one patient suffered a severe cardiopulmonary

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Box-ED

What's already known on the study topic?

Intra-hospital transport of critically ill patients is frequently required for diagnostic or therapeutic procedures that cannot be performed in the intensive care unit.

What is the conflict on the issue? Has it important for readers?

During transport, patients are at an increased risk of complications or adverse events.

This study was designed to determine the incidence and types of adverse events occurring during intra-hospital transport of critically ill patients.

How is the study structure?

This is a single-center prospective observational study done for 8 months at a tertiary care hospital for consecutive intra-hospital transport of critically ill 160 patients to and from the intensive care unit.

What does this study tell us?

Various critical events were noted during transport and classified into major and minor critical events.

The patients were most commonly transported for radiological imaging.

The main critical events were related to the airway.

Standard guidelines and monitoring need to be followed during intra-hospital transport of critically ill patients.

complication or expired during IHT per month in a 5-bedded ICU in a tertiary care hospital in Glasgow with 55 admissions in 5 months. Physiological changes such as in heart rate (HR), blood pressure (BP), respiratory rate (RR), and oxygen saturation (SpO_2) are commonly observed during transport in up to 10%–68% of patients.[3-5] The most common cause of the adverse event is equipment malfunction in 11%–34% of all transport events.[3-6] Knowledge about the potential complications associated with IHT is essential to determine the safest way to transport patients reducing mortality and morbidity. This observational study was designed to fill this epidemiological gap by determining the incidence and types of adverse events occurring during IHT of critically ill patients in a tertiary care hospital. Therefore, our study aimed to find the causes and incidence of critical events occurring during IHT of patients to and from ICU.

Methods

This prospective observational study was conducted after ethical clearance from the institute ethics committee for 8 months at a tertiary care hospital. After registering this in the Clinical Trials Registry of India (CTRI/2018/05/014236), all patients transported out of the ICU during the audit period for diagnostic procedures or to the operating room were included in the study after obtaining informed written consent. This study was planned in an 11-bedded ICU in those patients who were scheduled for transport out of the ICU for diagnostic or therapeutic procedures. A patient transport was defined as any transfer involving patients with a critical illness, requiring the presence of specially trained medical personnel. Transport-related critical events were defined as any event that could adversely affect the patient. A resident trainee along with a trained operation theater technician accompanied every patient. The medical personnel (anesthesia resident) involved in the transport defined critical events during transport. This team filled up the proforma designed for this study.

Our ICU universal transport trolley is 190 cm long and 75 cm wide, can bear up to 170 kg of weight. It can carry two B type oxygen cylinders, a portable monitor (Philips, Intellivue MP20, MP8001A, The Netherlands), a rechargeable portable ventilator (Drager, Oxylog 3000, ASJJ-0080, Germany) and infusion pump(s) (Infusor 950, SE32050 Syring Infusion Pump, Emco Meditek Pvt. Ltd., India). Preloaded syringes of emergency drugs and equipment to secure the airway are always taken along.

All our patients were adequately monitored according to the 2004 American College of Critical Care Medicine guidelines for IHT of critically ill patients. The following data were recorded before transport from ICU: primary and secondary diagnoses, "Acute Physiology And Chronic Health Evaluation II" (APACHE II) score on the day of admission to the ICU, the reason for IHT, the ongoing treatment, presence of peripheral and central venous lines, arterial line and drainage tubes, and details of the respiratory support (the mode of ventilation, fraction of inspired oxygen [FiO_2] and positive end-expiratory pressure [PEEP, HR, BP, Spo_2, and RR of the patients). Other details that recorded were the time of the IHT, whether on weekday or weekend transport, and the experience of the accompanying medical personnel. HR, BP, SpO_2, and RR were recorded after the patient was shifted from ICU to the required destination. Critical events during transport were noted. After the patient returned to the ICU, the following data were recorded again: BP, HR, RR, and the total time taken for IHT. The occurrence of critical events was correlated with the following factors: time of IHT (day/night), weekends/weekdays, total IHT time, the experience of the accompanying personnel, the presence or absence of inotropic support, the presence or absence of high PEEP (>8 cm H2O) or FiO_2 (>0.6), and APACHE score. Critical events were divided into those related to the airway, monitors, drugs and intravenous lines, equipment, cardiovascular system, respiratory system, and miscellaneous. We classified the events as major or minor critical events based on the presence and absence of potential consequences that lead to a change of therapy during IHT. Major and minor surgeries were

determined whether the body's cavity was exposed or not exposed, respectively.

In the present study, bradycardia was defined as HR <60/min; tachycardia was defined as 20% increase in HR from baseline (at the time from transfer from the ICU) or HR >180/min, desaturation was defined as SpO_2 <90%, and hypotension was defined as 20% decrease in mean BP from baseline or mean BP <60 mmHg for more than 1 min; hypertension was defined as 20% increase in mean BP from baseline or mean BP >110 mmHg for more than 1 min.

Statistical analysis

The IHT protocol in our ICU mandates that an anesthesia resident and a trained assistant accompany the patient with continuous monitoring and mechanical ventilation. Therefore, we expected that the complication rate should be near the lower end of the spectrum, at around 10%. A sample size of 139 was required to detect this complication rate with a 5 % error margin.

Data were entered into a database in Microsoft Excel 2016® and analyzed in a descriptive, inferential, and analytical way, through the total responses, percentage, and 95% confidence interval (95% CI) for the items of the questionnaire, or by measures of central tendency and variance. Descriptive analyses of the critical events were performed, and the incidence rate with 95% CIs was calculated. CIs were calculated using the one-sample test for binomial proportion. Nominal data were analyzed using the Chi-square test or Fisher's exact test. APACHE score was compared between those with critical events and those without using the Mann–Whitney U-test. $P < 0.05$ was considered statistically significant.

Results

In this study, 160 patients were studied for consecutive IHT to and from the ICU. Out of these, 97 were male (60.6%) and 63 (39.4%) were female. The baseline characteristics of the patients in the study are shown in Table 1. All patients subjected to IHT in this study were receiving a FiO_2 ≤0.5% and a PEEP of ≤8 cmH2O. Out of these, 149 (93.12%) patients were on mechanical ventilation (114 [71.25%]) on synchronized intermittent mandatory ventilation mode, 35 [21.87%] on continuous positive airway pressure), 6 (3.75%) on T-piece (total intubated patients = 155), 3 (1.87%) on venturi mask, 1 (0.62%) on nasal prongs, and 1 (0.62%) on room air.

Out of these 160 patients, 33 (20.6%) had hypertension, 10 (6.25%) had diabetes mellitus, 5 (3.1%) had coronary artery disease, 4 (2.5%) had Guillain–Barre syndrome, 3 (1.87%) had chronic obstructive pulmonary disease, 3 (1.87%) had pancreatitis, 2 (1.25%) had epilepsy, 2 (1.25%) had bleeding disorder, 1 (0.62%) had connective tissue disorder, 1 (0.62%) had chronic liver disease, 1 (0.62%) had chronic kidney disease, 1 (0.62%) had heart failure, and 1 (0.62%) had unknown poisoning.

Table 1: Baseline parameters and monitoring used

Parameters	Mean±SD or *n* (%)
Baseline characteristics	
Age (years)	38.0±19.6
HR (beats/min)	104.9±22.0
Duration (minutes)	51.3±37.4
RR (breaths/min)	18.7±6.3
SpO_2 (%)	98.6±1.7
APACHE score II (median [range])	15 (11-20)
Indication for ICU admission	
Traumatic brain injury	80 (50.0)
Neurological disease	28 (17.5)
Respiratory failure	12 (7.5)
Postoperative care	9 (5.6)
Others	25 (19.4)
Purpose of IHT	***n* (%)**
Radiodiagnosis	93 (58.1)
Minor surgery	
Alone	51 (31.8)
With radiodiagnosis	4 (2.5)
Major surgery	
Alone	4 (2.5)
With radiodiagnosis	2 (1.2)
Nerve conduction study	3 (1.8)
GI endoscopy	1 (0.6)
Vasopressors/inotropes used during transport, *n* (%)	
Noradrenaline	9 (5.6)
Dopamine	1 (0.6)
Adrenaline	1 (0.6)

SD=Standard deviation, HR=Heart rate, RR=Respiratory rate, SpO_2=Oxygen saturation, IHT=Intrahospital transport, APACHE score II=Acute Physiology and Chronic Health Evaluation II, ICU=Intensive care unit, GI=Gastrointestinal

The most common cause for admission to the ICU was traumatic brain injury (TBI) (50.0%), followed by neurological diseases (17.5%), respiratory failure (7.5%), postoperative care (5.6%), and others (19.4%) [Table 1]. The patients were most commonly transported for imaging studies (58.1%). The other reasons for transport were minor surgery (31.8%), major surgery (2.5%), and others (7.5%) [Tables 1 and 2]. A total of 248 critical events were observed in 104 IHTs (65%; 95% CI: 57.4%–72.1%). Hence, an average of 2.38 critical events per patient was noted during transport.

Out of 248 critical events, maximum were related to the airway (22.5%; 95% CI: 17.8%–26.5%). In airway-related critical events, increased secretions (19%) was most common, followed by endotracheal tube (ETT) kinking/obstruction (1.2%), tracheostomy tube/ETT block (1.2), displaced T-piece (0.8%), and ETT blood secretions (0.4%). There were 33 critical events due to

Table 2: Minor and major surgeries for which patients were transferred to and from the Intensive care unit

Name of procedure	*n* (%)
Minor surgery	51 (31.87)
Tracheostomy	49 (30.62)
Tracheostomy bleeding management (in operation theater)	2 (1.25)
Radiology + minor surgery	
CT head followed by tracheostomy	4 (2.5)
Major surgery	4 (2.5)
Decompression craniotomy	1 (0.62)
Cranioplasty	1 (0.62)
VP shunt	1 (0.62)
Embolectomy	1 (0.62)
Radiology + major surgery	
CT head followed by decompression craniotomy	2 (1.25)

CT=Computed tomography

cardiovascular cause (13.3%; 95% CI: 9.5%–18.0%). In cardiovascular-related critical events, tachycardia (6.5%) was most common, followed by hypotension (3.2%), hypertension (2.8%), arrhythmia (0.4), and bradycardia (0.4%). There was no major cardiovascular event such as cardiac arrest. There were 13 (5.2%; 95% CI: 2.9%–8.6%) respiratory system-related critical events. In the respiratory system-related critical events, tachypnea (2.8%) was the most common, followed by desaturation (2.0%) and bronchospasm (0.4%) [Table 3].

There were 31 major events among the 248 critical events (12.5%; 95% CI: 8.8%–17.1%). These occurred in 23 out of 160 (14.3%) patients. Twelve of these patients were transported for computed tomography (CT), 8 patients for minor surgeries, 2 for major surgeries, and 1 for nerve conduction study. The major events were as follows: hypotension in 8 (3.2%), hypertension in 7 (2.8%), desaturation in 5 (2.0%), kinked/obstructed ETT in 3 (1.2%), endotracheal block in 3 (1.2%), altered mental status needing securing airway in 2 (0.8%, 1 patient on venturi mask and 1 on nasal prongs), arrhythmia in 1 (0.4%), and bronchospasm in 1 (0.4%) [Table 4].

Vasopressors/inotropes were used in 11 patients (6.8%) during transport, in which 5 patients (3.1%) required change in vasopressor dose. The main reason for vasopressor/inotrope usage was hypovolemic and septic shock. All those patients in whom there was a change in vasopressor dose experienced critical events. Of the weekend transport, 14 patients out of 20, i.e., 70%, experienced critical events. This was similar to the 90 patients out of 140, i.e., 64.3%, critical events occurring during weekday transport (P = 0.616). Nine patients out of 19 (47.4%) experienced critical events during nighttime transport which was similar to the 95 out of 141 (67.4%) critical events occurring during daytime (P = 0.086). There was no statistically significant difference between the two periods. The APACHE score

Table 3: Critical events during transport

Events	*n* (%)
Airway related	47 (19.0)
Increased secretions	3 (1.2)
ETT kinking/obstruction	3 (1.2)
TT/ET block	2 (0.8)
T-piece displaced	1 (0.4)
ETT blood secretions	56 (22.5)
Total	
Equipment related	
Circuit disconnection	23 (9.2)
Lack of adequate suction	15 (6.0)
Orogastric tube accidental displaced	14 (5.6)
Infusion pump battery failure	1 (0.4)
Total	53 (21.3)
Monitor related	
Poor display of the waveform	17 (6.9)
Poor visibility of the monitor	13 (5.2)
Arterial line transducer malfunctioning	8 (3.2)
Lack of incompatible monitor in MRI room	7 (2.8)
Monitor malfunctioning	4 (1.6)
Total	49 (19.7)
Cardiovascular related	
Arrhythmias including bradycardia and tachycardia	18 (7.2)
Hypotension	8 (3.2)
Hypertension	7 (2.8)
Total	33 (13.2)
Respiratory system related	
Tachypnea	7 (2.8)
Desaturation (SPO_2 <90%)	5 (2.0)
Bronchospasm	1 (0.4)
Total	13 (5.2)
IV line and drug related	
IV line disconnection	2 (0.8)
Accidental displacement of the IV line	2 (0.8)
Difficulty in reaching the IV line	1 (0.4)
Inadequate length of the IV line	1 (0.4)
Total	6 (2.4)
Miscellaneous	
Restlessness	14 (5.6)
Communication gap	8 (3.2)
Delayed transport	8 (3.2)
Difficult to transfer patients from the trolley	6 (2.4)
Altered GCS	2 (0.8)
Total	38 (15.3)

ETT=Endotracheal tube, TT=Tracheostomy tube, IV=Intravenous, GCS=Glasgow Coma Scale, MRI=Magnetic resonance imaging, ET=Endotracheal tube, SpO_2=Oxygen saturation

within 24 h of admission in the ICU did not have any significant correlation with the occurrence of critical events (P = 0.115).

Discussion

There is an increased risk of complications/adverse events during transport to and from ICU, but it is necessary for some therapeutic and diagnostic procedures. In the

Table 4: Major and minor critical events during transport of patients

Major critical events	*n* (%)
Hypotension	8 (3.2)
Hypertension	7 (2.8)
Desaturation (SpO_2 <90%)	5 (2.0)
ETT kinking/obstruction	3 (1.2)
ETT block due to secretions	3 (1.2)
Altered mental status needing securing airway (1 patient on venturi mask and 1 on nasal prongs)	2 (0.8)
Arrhythmias	1 (0.4)
Bradycardia	1 (0.4)
Bronchospasm	1 (0.4)
Minor critical events	***n* (%)**
Increased secretions	47 (19.0)
Circuit disconnection	23 (9.3)
Poor display of the waveform	17 (6.9)
Tachycardia	16 (6.5)
Lack of adequate suction	15 (6.0)
Restlessness	14 (5.6)
Orogastric tube accidental displaced	14 (5.6)
Poor visibility of monitor in the procedure room	13 (5.2)
Communication gap	8 (3.2)
Delay in transport	8 (3.2)
Arterial line malfunctioning	8 (3.2)
Tachypnea	7 (2.8)
Lack of Incompatible monitor in MRI room	7 (2.8)
Difficult to transfer patients from the trolley	6 (2.4)
Malfunctioning monitor	4 (1.6)
T-piece displaced	2 (0.8)
IV line disconnection	2 (0.8)
Accidental IV line displaced	2 (0.8)
Bloody secretion	1 (0.4)
Infusion pump battery failure	1 (0.4)
Difficult reaching IV line	1 (0.4)
Inadequate length of the IV line	1 (0.4)

IV=Intravenous, MRI=Magnetic resonance imaging, SpO_2=Oxygen saturation, ETT=Endotracheal tube

present study, patients with TBI (50.0%) constituted the largest proportion undergoing IHT, followed by those with neurological disease (17.5%). Lovell *et al*.[7] have reported a similar incidence of 32% of patients with TBI. In our study, the patient's diagnosis did not influence the occurrence of adverse events similar to other studies.[7,8]

In our institution, an anesthesia resident along with a trained operation theater technician always accompanies the patients during IHT. The resident coordinated with the ICU team, the receiving personnel, and the patient's relatives. He monitors the vital signs of the patients and intervenes as required. Papson *et al*.[9] in their study found that when a qualified emergency physician accompanied the patient during IHT, there was less incidence of adverse events than when either a junior or senior resident of emergency medicine accompanied the patient. Parmentier-Decrucq *et al*.[10] found that a junior physician of anesthesia encountered a lower incidence of adverse events than the junior physicians of other specialties. There was no significant difference in the incidence of critical events between senior and junior residents in our study.

The most common destination in our study was the department of radiodiagnosis (58.1%), followed by the emergency operation theater complex for minor surgeries (31.8%). This again is consistent with the literature. Smith *et al*.[3] found that the CT scan room (44%) was the most common destination, followed by the operation theater (25%). The most common destination in such studies was the CT.[3,7,8,11] There was no relationship between the destination of IHT and the incidence of critical events in our study.

There are no Indian guidelines for monitoring of patients during IHT. However, according to the 2004 American College of Critical Care Medicine guidelines for interhospital transport and IHT of critically ill patients, the minimum requirements for monitoring patients during transport are continuous electrocardiography, pulse oximetry, intermittent measurement of BP, RR, and pulse rate.[12] All our patients were adequately monitored according to these guidelines and enabled us to easily detect critical cardiovascular (13.3%) and respiratory events (5.2%) during transport. However, monitor-related critical events constituted 19.7% of all events. These constituted 16% of the total adverse events in Lovell *et al*.[7] study. The incidence of monitor-related events, as well as those associated with other equipment, could have been prevented by better pretransport and intratransport measures such as double-checking of patient-monitor connections, preventing entanglement of leads, making sure that the monitor battery is fully charged before transport, carrying an extra battery during transport, and provision of compatible and appropriately place monitors in the magnetic resonance imaging room.

In the present study, 248 critical events were observed in 160 patients during 104 IHTs (65%). In other words, there were 1.6 events per patient undergoing IHT (range: 0–8). If we only considered the patients who suffered a critical event, there were 2.4 events per IHT. Our incidence of critical events is similar to the high end of the range of values reported in the literature, as by Papson *et al*.[9] (67.9%) and Lovell *et al*.[7] (62.0%). The most frequent categories of critical events in our study were airway related (22.5%), and equipment related (21.3%). Equipment-related events ranged from 9% to 34% in the literature. There were 31 major events among the 248 critical events (12.5%; 95% CI: 8.8%–17.1%) in our study. This is higher than that reported by Papson *et al*.[9] (8.9%) and Waydhas *et al*.[4] (8%). In our study, vasopressors/inotropes were used in 6.8% of IHTs. In

3.1%, the vasopressor infusion rate had to be changed. In Parmentier-Decrucq *et al*. study,[10] inotropes were used in 30.9% of IHTs and only 1.9% required change in inotrope dose. The low frequency of inotrope/vasopressor use in our study was due to our institutional protocol which discouraged relatively unnecessary IHT in patients requiring inotropic support. However, we needed to titrate the dose of inotropes in the unavoidable IHTs. This is almost certainly due to the use of gravimetric devices for the infusion of inotropes during IHT. The use of inotropes or the need to adjust the dose during transport did not influence the occurrence of adverse events in our study in contrast to Lovell *et al*. who found that inotropic support increased the incidence of critical events during transport.[7] Two of our patients (0.8%) had a temporary decrease in the Glasgow Coma Scale by a score of one. Kue *et al*.[13] reported a 7% incidence of changing mental status in their study during transport.

Tracheostomy is one of the reasons for transferring ICU patients to the emergency operation theater. Indication for this IHT can be reduced by planning these procedures at the bedside by the percutaneous method. Furthermore, if an operation theater is attached to the ICU; it may further decrease the number of critical events. If IHT is still unavoidable, then a decision should be made balancing the necessity and urgency of the procedure along with the clinical status of the patient.[7] A pretransport checklist can decrease the number of these critical events. Communication with personnel at the destination should be performed before IHT. Brunsveld-Reinders *et al*.[14] developed an intrahospital checklist to guide physicians and nurses for the safe transport of ICU patients to another department. They further proposed that other hospitals can modify this according to their situations. In the present study, no critical event led to the permanent injury of any patient. This can be due to a qualified and trained team who accompanied the patients during IHT with adequate and appropriate monitoring which detected critical events in time and managed them competently.

There were several limitations to the present study. First, it was a single-center study lacking external validity. The definition of critically ill patients was not defined in our study. Many patients were transported multiple times for various reasons, resulting in selection biases for patients. There was no individual resident assigned for the transport of patients creating observer bias among residents. Some residents did not know the exact protocol of the transport, so they might have underreported some of the adverse events. We did not formulate any protocol after reporting adverse events during the transport which could have reduced the rate of complication in the future.

Conclusions

Critical events during IHT are common in critically ill ICU patients. However, it is essential to transport ICU patients for either diagnostic or therapeutic procedures. Standard guidelines about the accompanying personnel and monitoring need to be followed during IHT. Implementation of pretransport checklists and prompt communication with the staff at the destination should be enforced to further minimize the risk of critical events and major adverse events. Conduct of minor surgical procedures in the ICU and better bedside diagnostic procedures may be considered for the future.

Authors contributions statement

- MQP designed the study, acquired the data, analyzed the data, performed the statistics, and wrote the manuscript
- LNY designed the study and supervised the analysis
- KK supervised the design of the study, the data acquisition, and the analysis
- VS analyzed the data and reviewed the manuscript
- AS revised the manuscript and suggested changes and improvements.

Conflicts of interest

None declared.

Funding

None declared.

Consent to participate

All patients consented to participate to the study. Signed consent forms available from the authors.

Ethical Approval

This prospective observational study was approved by the institutional ethics committee of the Postgraduate Institute of Medical Education and Research, India with the Ethical clearance letter no NK/MD/1006/13492-93. Date: 2018.

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