Brief Communication

Intrahospital transport of mechanically ventilated intensive care patients using new equipment attached to a transfer board

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Aim: Multiple lines and tubes often complicate bed transfer in critically ill patients. To solve this problem, the authors developed medical equipment attached to a transfer board (“transfer board tree”) that integrates the patient, transfer board, and medical equipment. The objective of this study was to evaluate the efficiency and safety of the transfer board tree.

Methods: Forty mechanically ventilated patients (20 transfer board tree, 20 conventional) in the intensive care unit who were transported for computed tomography were enrolled. Transfer times and adverse events were recorded.

Results: Transfer board tree patients had significantly shorter transfer times. There were two adverse events only in the conventional group.

Conclusions: The transfer board tree enables rapid intrahospital transport of intensive care patients with sufficient monitoring.

Key words: Critically ill patient, intrahospital transport, mechanical ventilation, transfer board

INTRODUCTION

CRITICALLY ILL PATIENTS often require mechanical support. Multiple lines and tubes complicate patient bed transfer, resulting in an increased risk of medical accidents. A transfer board for trauma (TB) is mainly used during the trauma patient’s initial assessment. In order to keep a patient bed transfer more efficient and safe, the authors developed medical equipment that attaches to the TB, called a “transfer board tree” (TBT), that integrates the patient and medical equipment required (Fig. 1). The purpose of this study was to evaluate the efficiency and safety in intrahospital transport (IHT).

METHODS

THIS PROSPECTIVE, OBSERVATIONAL study was carried out in the intensive care unit (ICU) of Chiba

University Hospital (Chiba, Japan). Patients in the ICU are monitored continuously by intensivists. In this study, an ICU physician was selected as the leader of IHT. The ICU physician monitored the patient’s vital signs and determined ventilator settings and drug administration during transport. An ICU nurse recorded the time course, patient vital signs, and adverse events during IHT. This study protocol was approved by the Institutional Review Board at Chiba University, which waived the requirement for written informed consent because this was an observational study. All study data were collected either by the primary investigator or one of the co-investigators of this study.

Patients

Study subjects were mechanically ventilated critically ill patients who were transported within the hospital for computed tomography (CT) between April 2013 and March 2014. Patients who needed the following medical equipment were enrolled: (i) ventilator, (ii) pulse oximeter, (iii) electrocardiography monitor, (iv) invasive arterial pressure monitor. Patients were randomly assigned to a conventional or TBT group. Forty patients were enrolled, and they were assigned by the envelope.

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Fig. 1. Schema of the transfer board tree (TBT). The transfer board tree is attached to the foot end of the transfer board for trauma (TB). By mounting the TBT to the TB, it is possible to integrate the patient, the TB, and the medical equipment (e.g., monitoring devices, portable ventilators, infusion or blood transfusion products, blood/fluid warming units, infusion pumps, chest drainage bags, and urine bags). Radiography and computed tomography can be carried out on the TB because of its X-ray transparency.

Transfer board for trauma and TBT

The TB Model 2010 (Ferno Japan, Tokyo, Japan) was used in this study. Computed tomography could be carried out without removing the TB because of its X-ray transparency, and its weight is 5.9 kg. The TBT (Back Board Tree; SISM, Saitama, Japan) is an attachment designed to fit the TB. The TBT is made from stainless steel, and its weight is 9.3 kg. Monitoring devices, ventilators, infusion pumps, and urine bags can be hung on the TBT (Fig. 1). The TBT is attached to the caudal side of the TB. Computed tomography examination from the head to the knee can be carried out by “head first” position without removing the TBT.

Measurements

We recorded baseline characteristics and medical treatment required in IHT. The transfer times were recorded as follows: arrival at the CT room, preparation for CT (when the CT radiologist began scanning), CT completion (when the scan was completed), and discharge from the CT room; pre-CT (time between arrival and preparation for CT) and post-CT (time between CT completion and discharge) transfer time. In the TBT group, TBT preparation time (time between laying the TB under the patient and leaving the ICU was also recorded). Changes in physiological data before and after IHT were recorded; arterial partial pressure of oxygen/inspired oxygen fraction ($\text{PaO}_2/\text{F}_i\text{O}_2$), respiratory rate, heart

rate, and mean arterial pressure. Adverse events related to lines or tubes were also recorded.

Statistical analysis

Data are presented as mean $\pm$ standard deviation, or absolute numbers and percentages. The authors tested using a *t*-test for continuous data and Fisher’s exact test for categorical data. The statistical software package IBM SPSS Statistics, version 22 (IBM, Chicago, IL, USA), was used, with *P*-values <0.05 considered statistically significant.

RESULTS

THERE WERE NO significant differences in baseline characteristics between the TBT group and the conventional group (Table 1). Pre-CT transfer times for the TBT group and the conventional group were 3.5 ± 1.5 min and 6.4 ± 2.5 min, respectively ($P < 0.001$); post-CT transfer times were 2.3 ± 1.4 min and 4.0 ± 1.4 min, respectively ($P < 0.001$) (Fig. 2). The TBT preparation time was 11.8 ± 5.3 min. In both groups, there was no significant trend for changes in $\text{PaO}_2/\text{F}_i\text{O}_2$, respiratory rate, heart rate, or mean arterial pressure (Table 1). There were two adverse events only in the conventional group (disconnection of monitoring cable [$n = 1$] and accidental peripheral venous catheter removal [$n = 1$]).

Table 1. Baseline characteristics and comparison of physiological parameters between before and after intrahospital transport (IHT) of intensive care patients using a transfer board for trauma alone (conventional group) or with a transfer board tree (TBT group)

	TBT (n = 20)			Conventional (n = 20)			P-value
Age, years	66.8 ± 12.6			62.5 ± 19.7			0.430
Gender, male	16 (80)			13 (65)			0.480
Weight, kg	66.9 ± 18.1			62.8 ± 10.4			0.400
APACHE II	33.4 ± 8.2			31.9 ± 8.2			0.570
SOFA on admission	10.8 ± 3.9			10.1 ± 4.7			0.610
SOFA on IHT	11.4 ± 4.3			9.1 ± 3.7			0.071
Admission diagnosis							
Post-cardiac arrest	3 (15)			3 (15)			
Sepsis/infection	6 (30)			6 (30)			
Trauma	5 (25)			3 (15)			
SAP/AHF	3 (15)			3 (15)			
NOMI	0 (0)			2 (10)			
Cardiovascular	3 (15)			1 (5)			
SAH	0 (0)			2 (10)			
Endotracheal tube							1.000
Orotracheal	15 (75)			16 (80)			
Tracheostomy	5 (25)			4 (20)			
PEEP, cm H ₂ O	8.3 ± 5.4			6.8 ± 3.1			0.290
Venous catheters							
Central	0.6 ± 0.5			0.5 ± 0.5			0.540
Peripheral	1.3 ± 0.9			1.2 ± 0.8			0.710
Vasopressor support	8 (40)			2 (10)			0.065
Infusion pumps	2.8 ± 1.5			2.3 ± 1.2			0.220
	Before	After	P-value	Before	After	P-value	
PaO ₂ /F _i O ₂	241 ± 69	231 ± 85	0.59	252 ± 99	232 ± 87	0.130	
RR, breaths per minute	23 ± 4.4	22 ± 6.4	0.23	23 ± 10	22 ± 7.4	0.086	
HR, b.p.m.	92 ± 19	91 ± 20	0.82	95 ± 24	93 ± 19	0.510	
MAP, mmHg	75 ± 17	77 ± 18	0.62	80 ± 13	76 ± 18	0.077	

Data are mean ± standard deviation or absolute numbers and percentages. *P*-values were calculated with the use of unpaired *t*-test for continuous variables or Fisher's exact test for categorical data. AHF, acute hepatic failure; APACHE, Acute Physiology and Chronic Health Evaluation; HR, heart rate; MAP, mean arterial pressure; NOMI, non-occlusive mesenteric ischemia; PaO₂/F_iO₂, arterial partial pressure of oxygen/inspired oxygen fraction; PEEP, positive end-expiratory pressure; RR, respiratory rate; SAH, subarachnoid hemorrhage; SAP, severe acute pancreatitis; SOFA, sequential organ failure assessment score.

DISCUSSION

THE AUTHORS EVALUATED the efficiency and safety of the TBT method. Transfer times were significantly shorter in the TBT group.

There is a risk of physiological deterioration during IHT in critically ill patients.^{1–4} Shortening IHT duration with sufficient monitoring ensures patient safety.^{5,6} However, sufficient monitoring increases the risk of equipment-related adverse events,^{2,4,7} and can be an obstacle to rapid bed transfer. The authors hypothesized that if lines and monitoring equipment could be connected to the TB, these dilemmas would be

eliminated. In accord with expectations, the TBT reduced bed transfer times by 45% (pre-CT) and 42% (post-CT) compared to the control.

Intrahospital transport has been a significant risk factor for ventilator-associated pneumonia because of endotracheal tube displacement⁸ and is associated with significant worsening of oxygenation.⁹ There were no significant changes in physiological state in this study. This might be because the incidence of physiological change was lower than previously reported^{3,4} or the sample size was small. Adverse events related to lines and tubes did not occur in the TBT group. Because the distance from line or tube insertion sites to the

Fig. 2. Pre- and post-computed tomography (CT) intrahospital transfer time in intensive care patients transported using a transfer board for trauma alone (conventional group, $n = 20$) or with a transfer board tree (TBT group, $n = 20$). Pre-CT transfer times for the TBT group and the conventional group were 3.5 ± 1.5 min and 6.4 ± 2.5 min, respectively; post-CT transfer times were 2.3 ± 1.4 min and 4.0 ± 1.4 min, respectively. Transfer times were significantly shorter in the TBT group ($P < 0.001$).

TBT did not alter, the possibility for displacement was potentially lower. The TBT method could solve safety dilemmas associated with IHT.

To perform the TBT method, we have to lay the TB under the patient and attach the TBT on the TB. Ten minutes is spent in the ICE for preparation, therefore it is safe. In this study, TBT preparation did not involve any adverse events. Even if unexpected trouble did occur, it would be managed well because it is carried out with adequate monitoring in the ICU. However, TBT still has two problems, the cost and the weight. The TBT is made to fit the monitor and ventilator of each hospital, and the price is approximately ¥350,000. The weight of the TB and TBT combined is approximately 15 kg. The foot end of the TB becomes heavy, and care should be taken with the craniocaudal balance.

This study has several limitations. First, as it is a single center study, it does not account for variations in equipment or staff among different institutions. Therefore, the difference in transfer time may not be applicable to other facilities. Second, patients were randomly assigned by the envelope method. The medical staff, however, could not be blinded to the results of this grouping, which made it difficult to preclude any treatment bias. In the future, multicenter, randomized controlled trials should be carried out based on this pilot study. Despite these limitations, the TBT is considered a useful IHT method for critically ill patients.

CONCLUSIONS

TRANSFER TIME WAS significantly shortened with the use of the TBT for mechanically ventilated critically ill patients. The TBT method enables rapid IHT while allowing adequate patient monitoring.

CONFLICT OF INTEREST

YOSUKE MATSUMURA INVENTED the Transfer Board Tree. Chiba University and SISM Corporation (<http://sism.co.jp/>) jointly applied for the patent in Japan, which was received in August 2013 (Medical equipment attachment for transfer board, Patent in Japan #5344359). The authors did not receive any funding for this research.

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