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Road trips and resources: there is a better way

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Abstract

Background: Transport of critically ill patients for diagnostic and/or therapeutic management involves significant consumption of resources. In an effort to improve the delivery of care to these patients and decrease resource utilization, Hill-Rom (Batesville, IN, USA) have developed a self-contained device (CarePorter^{TM}) designed to provide both intensive care unit (ICU) support and transport capability. We hypothesized that the use of the CarePorter when compared with a standard or specialty bed (with transfer to a stretcher) would decrease the number of personnel and time required for transport without altering the current ICU standards of care.

Results: Over a 3 month period, 35 ventilated patient transports were divided into the following groups: specialty bed to stretcher (n = 13), standard bed (n = 9) and CarePorter (n = 13). The APACHE II score at the time of transport was not different between the groups, nor was the ongoing care being delivered. The CarePorter group had a statistically greater fractional inspiration of oxygen and positive end expiratory pressure, when compared with the other two groups ($P < 0.05$). The use of the CarePorter device decreased the number of personnel required to transport a patient (2.1 ± 0.3 *vs* 3.6 ± 0.5 for the standard bed and and 3.2 ± 0.7 for the specialty bed; $P = 0.0001$). The CarePorter also decreased the number of resources utilized for the preparation of a patient for transport ($P = 0.001$) when compared to the other groups. This was primarily due to the transfer of patients from specialty beds to a stretcher. Overall respiratory therapy time was also much less with the CarePorter (5.9 ± 5.7 min), when compared with the standard (26 ± 10 min) or specialty bed (22 ± 11 min) ($P = 0.0008$). In addition, the CarePorter group also had a higher nursing satisfaction score with the overall transport ($P = 0.008$).

Conclusions: Use of the CarePorter device resulted in maximization of the delivery of patient care, time savings, significantly improved utilization of escort personnel

critically ill patient intrahospital transport, resources

Introduction

Transport of critically ill patients for diagnostic evaluation or intervention in the hospital is essential, but not without risk [1-4]. The amount of time involved to coordinate a road trip, the number of personnel and resources utilized to perform the trip safely, and the effect of the road trip on the remaining staff members and patients in the intensive care unit (ICU) has not been well studied [5]. The American Association of Critical Care Nurses (AACN) and the Society for Critical Care Medicine (SCCM) have developed and published standards for intrahospital transport [6]. Nurses, physicians and transport personnel are required to provide the same level of care during the transport as is provided to the patient while in the ICU. Transport systems to facilitate the ease and safety of intrahospital transport of adults are not currently well developed. However, a 'total care' transporter for neonates has been available for many years.

New technologies are constantly being developed to improve patient care and to facilitate care of critically ill patients. In an effort to provide 'seamless care' to a patient, Hill-Rom (Batesville, IN, USA) have devised a product that manages the ventilator and iv pumps in the room and attaches to the patient's bed for transport. This self-contained device, the CarePorter^{TM}, is designed to provide the flexibility of both in-room ICU support and transport capability. Since an ideal intrahospital transport system is not currently available, we chose to study the CarePorter during development. This study was specifically designed to compare the resources utilized to safely transport against the new CarePorter device. The CarePorter is able to move as a single unit

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and, therefore, we hypothesized that its use would decrease the number of personnel and time required for transport of the ventilated patient without altering the current standards of care. In this study, the CarePorter demonstrated decreases in both personnel time and resource utilization.

Materials and methods

All mechanically ventilated surgical ICU (SICU) patients undergoing scheduled or emergency transport were eligible for participation in this study. The CarePorter is a product designed by Hill-Rom to provide 'seamless care' to the critically ill. The CarePorter houses the ventilator, iv poles and other equipment in the room, but can be coupled to the bed for transport. The device is battery driven during transport to supply power to the ventilator (Fig 1). Portable oxygen and air tanks (two each) located on the CarePorter supply the ventilator during transport. The device can easily be reconnected to a wall source at the destination, or the tanks may run for a minimum of 90 min, depending on the patients ventilatory requirements. Thus, the CarePorter provides uninterrupted ventilation, maintaining the patient on the same in-room ICU ventilatory support. Moving as a single unit, the CarePorter is designed to provide ICU level care within the footprint of the bed (Fig 2). This advance in technology assists in providing ICU level of care during transport, and theoretically decreases the number of resources necessary to safely transport a patient to the test site.

For inclusion in this study, patients were divided into two groups, depending on whether or not they required a specialty care bed providing a unique surface for management of wounds and skin. This requirement was

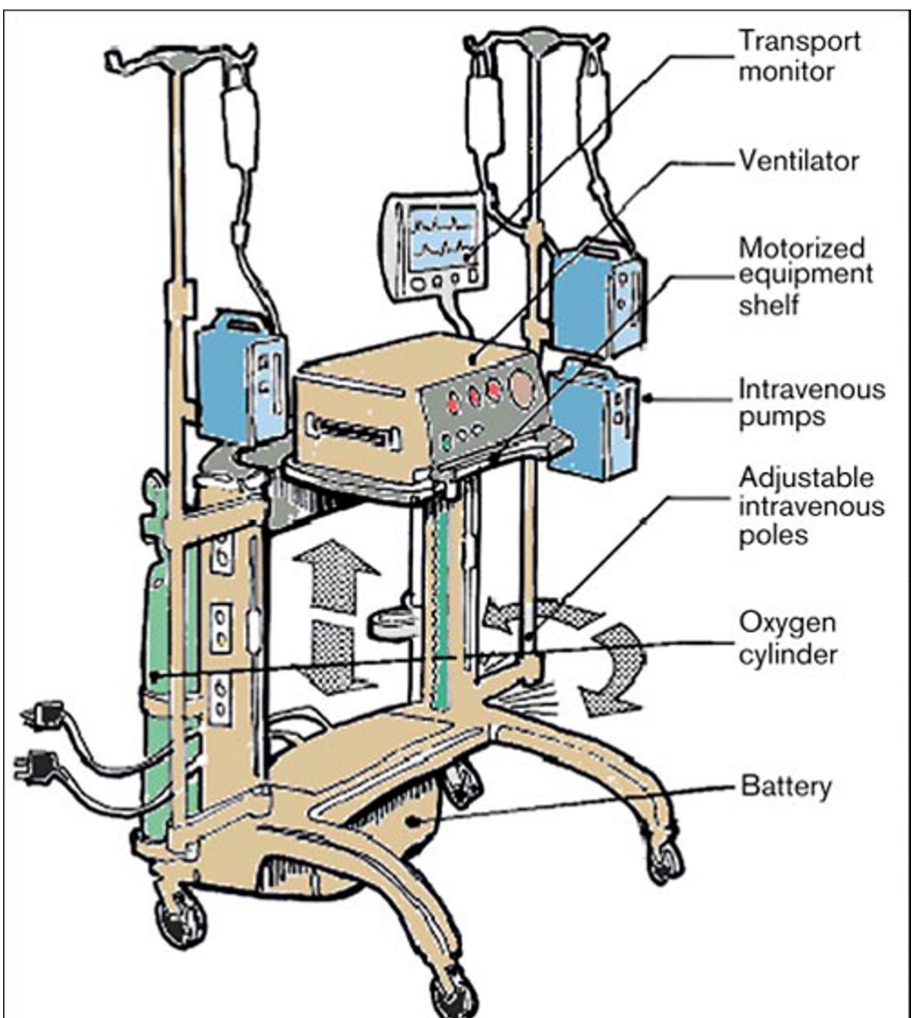

Figure 1 Schematic of the CarePorter device showing the important features. Specifically note portability, position of battery and location and quantity of air and oxygen tanks.

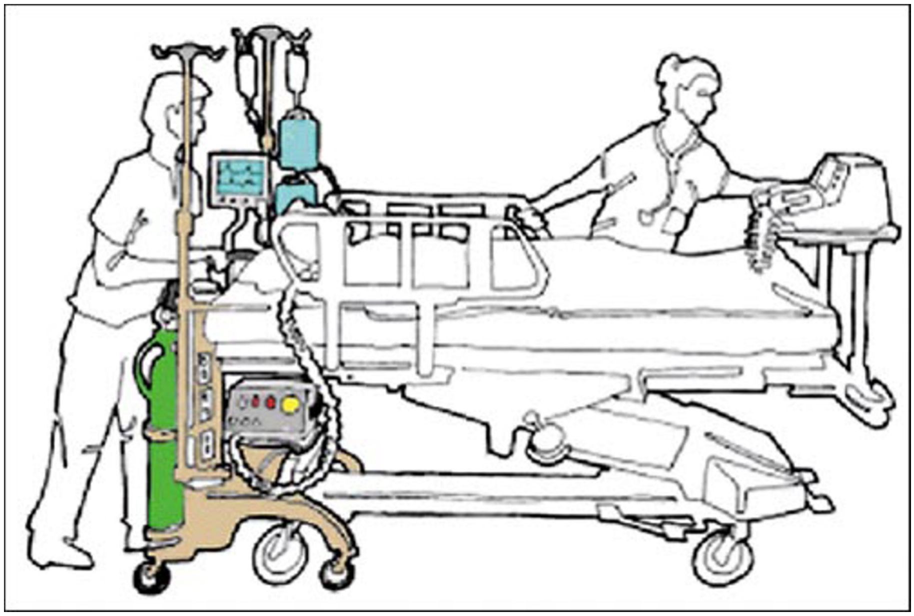

Figure 2 CarePorter device coupled to bed for transport. In the intensive care unit the device may be coupled or uncoupled depending on staff preference.

determined outside the limits of the study by the attending physician. Our practice is to transfer patients from specialty care beds to a stretcher for transport. Due to the size and mobility of these air surface mattresses, we have determined that the ease of transport is improved by transferring the patient temporarily to a stretcher. Specialty bed patients were included in this study because a similar quality air surface mattress was not available at the time with the CarePorter bed. This patient group historically comprised 30-40% of all transported patients. The remaining patients without special care needs were then randomly divided into a standard transport group and a CarePorter transport group. Patients in the standard bed group were transported directly on their bed with the nurse, physician and ancillary personnel necessary to manage iv poles and accessory equipment. During the transport, the physician provided manual ventilation, while the respiratory therapist transported the ventilator in a separate elevator to and from the test site. All eligible patients were considered and then randomized based on the availability of informed consent and the transport bed (two available). In four patients, the critical care physician not involved in the conduct of the study felt that the patient was too compromised from a respiratory standpoint to undergo manual ventilation, or to use a transport ventilator. The CarePorter allows continued uninterrupted ventilation with the in-ICU ventilator; therefore, these four patients were considered candidates for transport with the CarePorter group only. These four patients would not have been transported without this device, and could therefore bias the data because more ill patients were stratified to the CarePorter group. The study was approved by the Institutional Review Board and all patients or surrogates transported with the CarePorter provided written informed consent.

All three groups, specialty bed (SB), standard (S), and CarePorter (CP), were subject to analysis of resource utilization, and time and motion studies performed by study personnel. Our hospital standard of care requires that all critically ill patients be transported with a critical care nurse, a physician and a respiratory therapist (if the patient is mechanically ventilated). Extra escort personnel are required as necessary to transport additional equipment depending on the particular patient. The need for these escort personnel was determined by the bedside nurse caring for the patient and not by anyone involved in the study. In all groups the time required for the respiratory therapist to be involved was recorded. However, the respiratory therapist was not included in the numbers as a resource for transport. In the SB and S groups, the respiratory therapist transported the ventilator to the test site and attached the patient to his/her SICU ventilator settings. When the test was completed, the respiratory therapist would return to the test site, transport the ventilator to the SICU and reconnect the patient when ready. In the CP group, the respiratory therapist's only function was to connect the patient to the test site oxygen and air supply when the time spent away from the SICU exceeded 60 min. A study coordinator observed each transport, and recorded the number of personnel and time involved for each aspect. Each transport was divided into the following four time periods:

1. preparation for transport,
2. the transport itself,
3. times spent at the destination, and
4. the period between the end of the transport and return to baseline.

Patient demographics, diagnosis, degree of illness at the time of transport as measured by APACHE II score, the number and type of personnel, and equipment utilized during the transport were recorded. Any adverse events that occurred during the study period were noted in all groups. Physiologic data were collected and analyzed separately. Additional responsibilities of the transporting nurse and respiratory therapist for patients remaining in the intensive care unit were carefully noted and the impact on the patients and staff remaining in the unit was monitored.

All SICU nursing and respiratory personnel attended an educational lecture regarding intrahospital transport and the CarePorter device prior to initiation of the study. The study coordinator was responsible for data collection only and did not assist with the transport, but was available each time to answer specific questions regarding the CarePorter. The study coordinator conducted all time and motion studies and administered a satisfaction questionnaire designed to examine the concerns of the bedside nurse involved in intrahospital transport.

Using the statistical package Crunch (Verion 4, Crunch Software, Oakland, California, USA), the three groups were analyzed for differences using a one-way analysis of variance (ANOVA) test, where significance was accepted at $P<0.05$. For analysis of the cost and impact of the transport on the unit, the S and SB groups were combined and compared with the CarePorter group by Chi-square analysis. Data are presented as mean and standard deviation.

Results

The study consisted of 35 scheduled transports of critically ill patients from the SICU. All patients were mechanically ventilated. There were four female and 31 male patients with an age range of 28 to 85 years. The degree of illness at the time of transport as measured by an APCAHE II score was similar for all groups (20.8 ± 6.6). There were no statistical differences in the severity of illness or on-going therapies between the groups overall, except that the CP patients required a higher fractional inspiration of oxygen and positive end expiratory pressure than the other two groups ($P < 0.05$). Twenty-seven patients were transported for a diagnostic computerized tomographic scan (CT), while five patients were transported to interventional radiology. Two patients were transported to the operating room and one patient for a lung scan. Time spent at the test site did not differ between the groups (25 ± 5.2 min), nor was time dependent on the destination.

Nine patients were transported via a standard ICU bed and 13 were transported via the specialty bed/stretcher. Thirteen patients were transported via the CarePorter. Data from the time and motion studies are shown in Table 1. No significant difference between the groups was observed in the time taken for the nurse to prepare for the transport. Mean transit times were less than 5 min both to and from the test site in all patient groups. The time required for the nurse to re-establish the patient's pre-transport status upon return to the SICU was significantly different between the groups, with the CarePorter having the shortest recovery time (10.7 ± 7 min; P = 0.001) when compared with the specialty/stretcher (17.8 ± 5.2), and the standard bed (22.8 ± 8.3). In addition, the groups were significantly different with respect to the number of transport personnel required. The CP group required 2.1 people, significantly less than the SB and S groups which required 3.2 ± 0.7 and 3.6 ± 0.5, respectively (P = 0.0001). Because the specialty beds were not used for transport, with patients being transferred to a stretcher, this group incurred additional personnel time (21 ± 17 min) which the others did not.

Assessment of the cost savings involved in diminishing resource utlilization includes nursing time, respiratory time (discussed below) and escort personnel time. Compared to the current S or SB transfer group an average of one escort person is saved per transport. Since these personnel are involved on an average transport for about 40 min, assuming 100–200 transports/unit/year (15 beds) and 1000–2000 transports per year in our hospital, approximately 40,000–80,000 min/year (666–1333 h/year) could be saved. Since escort personnel are paid just above minimum wage, the cost savings might range from $4000–8000 per year. For nursing personnel, the calculations for cost savings are more difficult to delineate because the underlying assumption is that personnel number can be decreased with this device. With nursing personnel the number required does not decrease, but the amount of stress placed on the nurses who remain

Table 1 Personnel time for patient transport

Group	Ready time (min)	Return to baseline time (min)	Number of transport personnel
Standard	32 ± 20	23 ± 8	3.6 ± 0.5
Specialty bed	26 ± 2	18 ± 5	3.2 ± 0.7
CarePorter	18 ± 15	11 ± 7*	2.1 ± 0.3†

*P = 0.0013, †P = 0.0001.

behind in the unit and on the nurse transporting the patient is diminished.

Respiratory therapist time was also affected by the mode of transport (Table 2). The mean time for the respiratory therapist to be ready for a transport was 5.3 ± 4.7 minutes, and did not differ between groups. The time that the respiratory therapist was involved with the transport (including time spent at the test site) varied. Time involved with the CP group (5.9 ± 5.9 min) was significantly less than with the SB and S groups (22.0 ± 10.9 and 26.4 ± 9.9 respectively; P = 0.0008). Thus, without changing the requirement for the therapist to attend a transport, about 20 min of respiratory therapy time is saved per transport using the CarePorter device. Depending on the total number of transported mechanically ventilated patients (100–200 per year in our unit alone), respiratory time savings through use of the CarePorter can be estimated. Assuming 1000–2000 transports of mechanically ventilated patients per year, in a hospital with 100–150 ICU beds, respiratory time savings of 20,000–40,000 min (333–666 h/year), at a cost of between $5000 and $16,000, could be made.

The impact of the transport upon the workload of the unit and upon respiratory therapy coverage was also examined. In many circumstances, an ICU nurse was caring for more than one patient, depending on the severity of illness of the patients in the unit. When a nurse was assigned to the care of more than one patient and one of them required transportation, the care of the others was assumed by another nurse on the unit or the charge nurse, in both cases in addition to their routine responsibilities. In this study, the charge nurse usually assumed the responsibility of caring for the remaining patients. The covering nurse was responsible for total patient care, which ranged from simply monitoring and recording vital signs, monitoring for acute changes, intervention with families, and implementing changes in therapy, all performed while maintaining other responsibilities. In this study, there were no differences in the amount of missed nursing treatments or therapies between the groups. However, the CP group showed a significant difference in the time taken to return the patient to his/her pretransport status. Since transported patients in this group required less time and fewer personnel, there was minimal interruption in the routine care of remaining patients in the unit.

Table 2 Respiratory therapy time

Group	Ready time (min)	Total time (min)	Return to baseline times (min)
Standard	7.2 ± 6	26 ± 10	8 ± 5
Specialty bed	4.1 ± 2	22 ± 11	6 ± 5
CarePorter	5.1 ± 5.3	5.9 ± 5.7*	0.8 ± 0.7†

*P = 0.008, †P = 0.0004.

Nursing satisfaction with the overall transport process was rated on a scale of 0-10 (0 not satisfied, 10 most satisfied) and again significant differences were observed between the groups. (CP = 8.3 ± 1 *vs* SB = 6.0 ± 2.3 and S = 6.2 ± 1.9; P = 0.008).

The standard at our institution is for the respiratory therapist to accompany a ventilated patient during transport. Therefore, the unit required respiratory therapy coverage during the test period. In most cases this therapist was also responsible for another ICU. During this time period, respiratory therapy services were likely to delayed more often in the S/SB groups when compared to the CP group (P = 0.01), due to the overall additional time devoted to the transport.

Safety to personnel and patient was also assessed for the three groups. Though iv lines were inadvertently discontinued for times in the S/SB groups this was not significantly more than the once in the CP group (P = 0.39). Staff injury was also examined and occurred to a similar extent in both groups. Injuries were reported as minor and were related to space limitations in the elevator and excessive stretching. There were no major injuries reported to the staff or patients in this study.

Discussion

Intrahospital transport involves significant utilization of resources, personnel time and interruption of care delivered to a critically ill patient [5]. This study examined the utilization of these resources and the amount of time required to safely transport a patient to an in-hospital diagnostic test or procedure. The traditional means of transport was compared with a new self-contained device, the CarePorter, with in-room and transport capabilities. The use of the CarePorter device required less resource personnel to safely transport the patient to a diagnostic test or procedure when compared with current intrahospital transport. This decrease in personnel did not result in a decrement in care, or an increase in patient or staff injury in the CarePorter group. This decrease in utilization of resources is of paramount importance in an era of medicine where increased pressures to reduce cost are ever present.

In response to complications that occur during intrahospital transport, Link *et al* designed a mobile transfer unit [2]. This could be attached to the patient's bed to provide power and gas for continuous treatment and monitoring of patients during transport. The system was designed in an effort to decrease changes in patients' level of care during transport and prevent complications. Since the introduction of the transfer unit for the study they experienced no unanticipated problems during intrahospital transport. This study supports the concept of the CarePorter device in providing streamlined patient care during transport, but did not address the savings in resource utilization.

Time, equipment and personnel are needed to transport a patient. The amount of time involved of the bedside nurse to ready a patient for transport includes the coordination of the equipment needed, such as the emergency drug bag, portable electrocardiographic monitor, portable O_2 saturation monitor and/or defibrillator, portable suction, and other equipment specific to the patients' needs. This must occur without compromising care to the patients assigned to the nurse. Not only does the equipment need to be readied, but also the patient must be prepared. This preparation includes psychological support to the patient and possible transfer to a stretcher. We found that there was no significant difference between the amount of time taken to ready a patient in each group. However, those patients who were transferred to a stretcher required on average an extra 21 min to ready. This time was direct time away from patient care. If the number of patients in this study were greater, the CarePorter group may in fact have demonstrated a statistical advantage in the time necessary to ready the patient for transport.

The location of the test site in relation to the ICU and the availability of the elevator determine transit time to a test site. Despite the perception that transit time is lengthy, it was surprisingly short, and did not depend on the mode of transport. Thus, the CarePorter device did not take longer to maneuver in and out of difficult areas such as elevators, which is a current criticism of the specialty bed and the reason that the patient is moved to a stretcher for transport.

Once the patient has returned to the SICU, he/she must be returned to pretransport status. This includes, but it not limited to, re-attaching the patient to the in-room monitoring system, arranging the iv pumps and poles straightening iv lines, straightening and or changing sheets, and the placement of drains to suction. All transported patients underwent this procedure; however, the amount of time required to return the patient to his/her baseline status was significantly different among groups. The average recovery time for the SB group was 22 min because time and personnel were required to transfer a patient back to the specialty bed from the stretcher. This action alone poses many risks to the patient, including extubation, discontinuation of lines and general discomfort, not to mention the possibility of back strain to the staff. The S group required 17.8 min to return the patient to his/her baseline status whereas the CP group required only 10.7 min. Because the pumps and ventilator were attached to the patient's bed, a simple disconnection of the device from the bed occurred. Thus, between 7-12 min per transport was saved during the return to baseline. This saving in time also improves the quality of care delivered to both the transported patient and those remaining in the ICU.

Depending on the acuity of the remaining patients in the unit and the responsibilities of those individuals covering patient care, nurses were not always able to complete routine care [5]. The transporting nurse must, therefore, assume this care upon return to the unit. This increase in workload of the remaining staff nurses may lead to increased stress [7]. The issue of care of the remaining ICU patients is critical. Unless a qualified outside team transports the patient to the test, leaving the staff nurse in the unit, the care of the other patients is affected [7]. Though we did not find a difference between the modes of transport with respect to the care of the patients remaining in the unit, any modality that decreases time taken arranging and conducting the transport is beneficial.

The nurses' satisfaction with the overall transport was greater with the CP group. Nurses were more satisfied because the device was easy to maneuver, all additional equipment was attached, there were no iv pole(s) to push and there was no need for manual ventilation. Coupling and uncoupling the device prior to and upon return to the SICU was easy and required minimal time. The patient was returned to baseline status more quickly and overall the CarePorter made the transport easier. Since intrahospital transport is a source of angst among staff, anything that can reasonably improve this process is warranted.

Since all patients were mechanically ventilated in this study the respiratory therapist was not included in calculating the number of transporting personnel. However, significant reductions in overall respiratory time were seen with the use of the CarePorter device. On average, 20 min of respiratory time per transport could be saved with the use of the CarePorter device. Since in a unit the number of intrahospital transports ranges from one to 10 per week (average of three), this could result in significant savings of respiratory therapy personnel time. However, unless the nurse assumes responsibility for connecting the air/oxygen tanks to the wall supply, the respiratory therapist would still need to accompany the patient to and from the test site. This task is simple, but would require additional education.

In addition to reducing respiratory therapy personnel time, the CarePorter provided a saving of one person per transport, with the overall time for transport of about 40 min for the standard bed, with an additional 40 min for transport of the specialty bed/stretcher group. Thus, savings of escort personnel would occur when a large number of transports are needed. The financial impact of this transporter depends on the standards for transport at a particular institution, and the number of transports of mechanically ventilated patients. The reductions in nursing time are more difficult to report in terms of actual cost savings for the unit because the workload of the transporting nurse is shifted to nurses remaining in the ICU. Improved efficiency is the expected outcome rather than reduced cost, with care that would not be provided because the transporting nurse was not present for a certain period being minimized as time away from the unit decreases.

The issue of patient and staff safety is important throughout the hospitalization, irrespective of the patient's location. Although every effort is made to prevent such incidents, inadvertent discontinuation of iv catheters, drains and iv fluid does occur during transport. Reports of these occurrences vary depending on data collection definitions for transport related complications [5,8-10]. There is also potential for minor staff injuries to occur during pushing the patient and equipment to the test site. In this study minor injuries occurred irrespective of the patient group. The advantage of the CarePorter should be that as all equipment is attached to the patient's bed and moves as one unit, the risk of injury is reduced; however, this may be offset by the fact that the CarePorter is a heavier device.

This study was a prospective trial of transports that occurred over a 3-month period. Randomization of patients was affected by a variety of factors including the presence of informed consent for use of the CarePorter device, the availability of the bed and CarePorter device, and the type of bed the patient occupied (either specialty bed or standard bed). Though there were no overall statistical differences between the patient in transport group, respiratory illness was more severe in the CP group. This selection bias occurred in four patients because of the severity of their respiratory illness. Both the attending SICU physician and the service attending physician did not believe transport of these patients with manual ventilation was safe, and would only allow the patient to be transported on a ventilator that was capable of providing the appropriate settings for the patient. Since these four patients were more ill than the standard transport patients, this bias could be expected to increase the work involved in the CarePorter group. However, this did not translate into additional time for nurses, respiratory therapists, or escort personnel. Therefore the continued development of devices such as the CarePorter which facilitate a difficult task such as the CarePorter which facilitate a difficult task such as intrahospital transport, and do so while reducing nursing, ancillary and respiratory therapist time, is a welcome cost saving addition to intensive care.

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