Running title: Ambulation status following ICU stay

Title: Exploring the capacity to ambulate following a period of prolonged mechanical ventilation

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ABSTRACT

Purpose: The purpose was to assess the functional recovery of those who survived a prolonged intensive care unit (ICU) stay by reporting the proportion who were able to ambulate independently at hospital discharge and also to examine if the time duration between admission and when the patient first stood impacted on their capacity to ambulate at discharge.

Materials and Methods: We conducted a retrospective review of medical records of ICU patients in 2007-8, mechanically ventilated for ≥ 168 hours and surviving their acute care stay. Main outcome measures were: (i) ambulation status prior to admission and at time of hospital discharge; (ii) time between admission to the ICU and when the patient first stood.

Results: A total of 190 patients were included. Prior to admission 189 (99%; 95% confidence interval [CI], 98 to 100%) were ambulating independently, of whom 180 (95%) did not require a gait aid. On discharge from acute care 89 (47%; 95% CI, 40 to 54%) were ambulating independently, of whom 54 (61%) did not require a gait aid. Compared with those who stood within 30 days of ICU admission, a delay in standing of between 30 and 60 days increased the odds five-fold (95% CI, 2 to 11) of being unable to ambulate independently at the time of discharge.

Conclusions: Following a prolonged ICU admission more than 50% of patients were unable to ambulate independently by hospital discharge, with the time between admission and first stand, being an important predictor of this outcome.

KEY WORDS:

Intensive care, mobility limitation, Outcome Assessment (Health Care)

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Patients who require prolonged mechanical ventilation (MV) in an intensive care unit (ICU) impose a substantial cost on the healthcare system [1, 2]. Those who survive are often characterized by long-term physical and mental impairments [3-6]. Although the primary goal of the healthcare team during periods of critical illness is to increase the likelihood of survival, the importance of early rehabilitation to optimize functional outcomes, such as the capacity to ambulate, is now well recognized [7-11]. Early mobilization of patients who require MV has been demonstrated to improve their ability to undertake activities of daily living independently, six-minute walk distance, quadriceps force and health-related quality of life [12, 13]. Despite the results of these earlier studies, the proportion of people who are capable of ambulating independently at the time of discharge from hospital following a period of prolonged MV is unclear. Few studies have reported this outcome and they have done so in highly selected groups of ICU patients [12, 13]. Specifically, patients with conditions likely to compromise functional outcomes, such as raised intracranial pressure were excluded from earlier reports [12, 13]. Determining the proportion of people who are able to ambulate independently at the time of hospital discharge following a period of prolonged MV, irrespective of the reason for admission to the ICU, will provide 'real life' insight regarding the impact of critical illness on functional status. It will also provide an appreciation of the ongoing need for support following discharge from acute care in this clinical population, as difficulty ambulating significantly increases the risk of not being able to manage in the community [14]. Further, among those who require prolonged MV, neither the proportion of people who sit out of bed, stand and walk during their acute care admission, nor the average time at which these milestones are first achieved has been clearly established. In a convenience sample of 30 tracheotomised patients Bahadur et al (2008) [15] reported that 63% of patients sat out of bed during their ICU stay. However, it is not clear whether enough emphasis is placed on rehabilitation and activity levels during the critical care episode. Although early mobilisation could potentially benefit certain patient groups, local expert consensus, let alone accepted evidence in the literature, has not defined standards of care for this aspect of management [15]. Such data are needed to provide realistic information to patients and their families regarding the time course of recovery and also to determine whether or not the time at which these milestones

are achieved has any impact on the capacity to ambulate independently at the time of discharge from acute care.

The primary aim of this study was to report the prevalence of patients who were unable to ambulate independently, with or without a gait aid, at the time of discharge from acute care following a period of prolonged MV. Secondary aims were to: (i) compare the characteristics of those who achieved independent ambulation versus those who did not, (ii) report the time between ICU admission and the attainment of specific functional milestones (e.g. sitting out of bed, standing), and (iii) determine whether or not the time between ICU admission and when the patient first stood impacted on their capacity to ambulate at the time of hospital discharge.

METHODS

Design and data extraction procedures

A retrospective audit of the medical records was undertaken by two investigators (SP, KH). Approval was obtained from the relevant Human Research Ethics Committees. Given that patients were not contacted, informed consent was deemed unnecessary.

A standardized form was developed. At the beginning of study, both investigators extracted data from the same eight medical records. Data were compared and the form was modified to optimize the extent to which both investigators extracted the same information. Thereafter, investigators sat together during the data extraction process and ambiguities regarding any variable were resolved via discussion.

For each patient who met the study criteria, data were extracted pertaining to: (i) demographic and anthropometric variables, (ii) type and severity of illness including Acute Physiology and Chronic Health Evaluation (APACHE) II scores [16], (iii) number of co-morbid conditions [17], (iv) management of the illness such as duration of MV, inotropic support and sedation as well as the use of intravenous or oral steroids, (v) attainment of functional milestones including the

capacity to ambulate at the time of discharge, (vi) length of stay in ICU and acute care, and (vii) discharge destination. For patients who had more than one volume of medical records, all volumes were recalled and reviewed. In addition to the integrated notes, all 24-hour ICU flow charts, prescription records, nursing observation charts and allied health notes were carefully inspected. The time taken to fully review and extract all data relevant to the current study was approximately 90 minutes per medical record.

Study criteria

Study criteria comprised: (i) admitted to our Level 3 ICU during 2007 or 2008, (ii) intubated and ventilated for ≥ 7 days (168 hours), and (iii) survived the ICU and subsequent hospital admission. We chose to study this sub-group as they require a disproportionate amount of total ICU resources [1] and are likely to have worse functional outcomes [1, 18]. The list of patients who met these criteria was developed using the relevant search fields from an in-house database of all ICU admissions. Where patients had multiple admissions during the study period, only data pertaining to their first eligible admission were included in the analyses. Details regarding the characteristics of these patients, together with the incidence of falls in this sample have been described previously [19].

Definitions

For the purposes of this study, sitting out of bed was defined as any period of time that the patient was transferred from their bed to into a chair of any description using manual handling equipment and/or through active patient participation, consistent with previous work [15]. Independent ambulation was defined as being able to walk, with or without a gait aid, but without the need for physical assistance or supervision from a healthcare professional; again this is consistent with the definition used in previous work [5, 12, 13]. We defined the length of hospital stay as the total time the patient spent in the acute care facility, which included the ICU stay; it did not include any time spent in another facility, such as a rehabilitation hospital or nursing home. Regarding attainment of functional milestones during the hospital stay, the date and time the patient first successfully sat out of bed, stood and walked were documented, irrespective of the level of assistance and support provided.

Statistical analysis

Data were entered into an electronic database (MS Excel 2003) and carefully cross-checked for accuracy. Analyses were undertaken using PASW Statistics V18 (SPSS Inc, Chicago, Illinois, USA). Proportions were calculated with their corresponding 95% confidence intervals (CI). The distribution of continuous variables was checked using frequency histograms. Descriptive statistics are reported as mean ± standard deviation or median [interquartile range] for parametric and non-parametric data, respectively. With patients grouped according to whether or not they could ambulate independently at the time of discharge, differences in proportions (e.g. males) were examined using z-tests with parametric and non-parametric continuous variables compared using independent t-tests or Mann Whitney U tests, respectively. Logistic regression was undertaken using the inability to ambulate independently at the time of hospital discharge as the dependent variable and the delay between admission to the ICU and the time a patient first stood as the independent variable. A probability level (p) of less than 0.05 was taken to represent statistical significance.

Sample size calculations

We estimated that 25% of patients who met our study criteria would be unable to ambulate independently at the time of discharge from an acute care facility. Prospective sample size calculations were undertaken to have reasonable precision around this estimate. A sample size of 190 patients would result in a 95% CI that spanned 6% above and below this estimate.

RESULTS

A total of 2,590 individual patients were admitted to our ICU during the study period, of whom, 190 fulfilled the study criteria (Figure 1). The sample was predominantly male (n = 126, 66%) and a 100 (53%) had a smoking history. The mean age was 52 ± 18 years and Acute Physiology and Chronic Health Evaluation II score was 20 ± 8. Median [interquartile range] length of stay in the ICU and acute care facility was 14 [10] and 42 [38] days, respectively. Median duration of MV in ICU, inotropic support and sedation was 13 [9], 3 [5] and, 7 [5] days,

respectively. A total of 30 (16%) patients were admitted to the ICU on more than one occasion and 56 (29%) required ongoing ventilatory support following discharge from the ICU. Reasons for admission to the ICU and characteristics of the sample are summarized in Table 1.

Table 2 summarizes ambulation status, pre-admission living arrangements and discharge destination. Prior to admission 189 (99%; 95% CI, 98 to 100%) were ambulating independently, of whom 180 (95%) did not require a gait aid. On discharge from acute care 89 (47%; 95% CI, 40 to 54%) were ambulating independently, of whom 54 (61%) did not require a gait aid. Exclusion of those who were admitted with a neurological injury revealed that, on discharge from acute care 69 (57%; 95% CI, 48 to 65%) were ambulating independently, of whom 37 (54%) did not require a gait aid. Prior to admission 188 (99%; 95% CI, 98 to 100%) were living at home and, following their acute care stay, 76 (40%; 95% CI, 33 to 47%) were discharged home.

The characteristics of the patients, grouped according to whether or not they were ambulating independently at the time of discharge from acute care are summarized in Table 3. Regarding categorical variables, there was no difference in the proportion of males (66 vs. 66%; $p = 0.88$), those who required multiple admissions to the ICU (16% vs. 16%; $p = 0.86$) nor those who required oral or intravenous corticosteroids for more than 24 hours (47% vs. 42%; $p = 0.53$). In contrast, the group who could ambulate independently at the time of discharge were characterized by a smaller proportion who had been admitted with a neurological insult (22% vs. 48%; $p < 0.001$). This smaller proportion was largely due to a difference in the proportion of patients admitted with a traumatic brain injury (12% vs. 27%; $p = 0.02$), rather than other causes of neurological injury such as subarachnoid haemorrhage or Guillain-Barré syndrome (10% vs. 21%; $p = 0.07$).

With regards to the attainment of functional milestones, 183 (96%) patients sat out of bed during their acute care stay. Of these 124 (65%) achieved this milestone during the ICU admission. The median time between admission to the ICU and when the patient first sat out

of bed was 13 [8] days. A total of 163 (86%) patients stood during their acute care stay. Of these, 42 (22%) achieved this milestone during the ICU admission. The median time between admission to the ICU and when the patient first stood was 19 [19] days. A total of 155 (82%) patients walked during their acute care stay. Of these, 15 (8%) achieved this milestone during the ICU admission. The median time between admission to the ICU and when the patient first walked was 23 [21] days.

Using the time between admission to the ICU and when the patient first stood categorized as: (i) < 30 days, (ii) between 30 and 60 days, and (iii) > 60 days, there was a progressive reduction in the proportion of people who could ambulate independently at the time of discharge. Logistic regression analysis demonstrated that, compared with those who stood within 30 days of admission to ICU, a delay in standing of between 30 and 60 days increased the odds of not being able to ambulate independently at the time of discharge five- fold (95% CI, 2 to 11). Compared with those who stood within 30 days of admission to ICU, a delay in standing of greater than 60 days increased the odds of not being able to ambulate independently at the time of discharge 28-fold (95% CI, 6 to 122).

DISCUSSION

The novel and important findings of this study are: (i) following a period of prolonged MV, less than 50% of patients could ambulate independently at the time of hospital discharge and of those who could, many required a gait aid, (ii) compared with those who could ambulate independently, those who could not were more likely to have been admitted with a neurological insult due to trauma, stay longer in both ICU and the hospital, as well as take longer to achieve functional milestones such as sitting out of bed, standing and walking, (iii) despite a culture of early mobilization in our ICU, only 65%, 22% and 8% managed to sit out of bed, stand and walk in the ICU, respectively, and (iv) an increase in the time between admission to the ICU and when the patient first achieved standing substantially increased the odds of not being able to ambulate independently at the time of hospital discharge.

Ambulation status following ICU stay

The impact of critical illness on physical and mental outcomes is a growing interest area. Previous studies have reported a loss of independence with activities of daily living or compromised physical function following discharge from hospital [1, 3, 5, 20]. Physical function following discharge seems to improve with time [5], with some patients reporting minimal impairment six months following ICU admission [21]. Nevertheless, the elderly [20, 22] and those who require multiple ICU admissions [23] or prolonged periods of MV [3], particularly related to acute respiratory distress syndrome [5, 6], appear to have deficits that persist for several years. The few studies that have reported functional status of patients following an ICU admission at the time of hospital discharge have done so in a relatively modest sample of survivors ($n < 100$) and excluded those at greatest risk of poor functional outcomes (e.g. raised intracranial pressure, poor prognosis) [12, 13]. Our findings extend these earlier reports by describing the proportion of people who could ambulate independently at the time of hospital discharge following a period of prolonged MV, regardless of the cause of ICU admission or the prognosis during ICU stay, in a larger sample size. Further, we demonstrated that although 47% were ambulating independently, 39% of these patients needed a gait aid to do so. Even with those who sustained a neurological injury excluded from the sample, the proportion of people who could ambulate independently was only 57%, and of these, nearly half needed a gait aid to do so. This is an important finding given that prior to admission, almost our entire sample was ambulating independently without a gait aid. Although many studies that examine functional independence do not separate patients based on their need for gait aids [5, 12, 13], we considered this important as the average age of our sample was only 52 years. Those who were dependent on a gait aid at the time of hospital discharge were likely to have required further rehabilitation services to achieve safe ambulation that was independent of gait aid. This is supported by finding that only 2% of patients were discharged home without some form of assistance or rehabilitation service; data highlighting the healthcare costs and caregiver burden following their acute care admission.

Compared with those who were able to ambulate independently, those who could not were characterized by a longer length of stay in both ICU and hospital. Although similar in APACHE

II scores, age, weight and number of co-morbid conditions, those who were able to ambulate independently at the time of hospital discharge also achieved functional milestones such as sitting out of bed, standing and walking much earlier. This information suggests that healthcare professionals may be able to use the early attainment of functional milestones as a marker that the patient is more likely to achieve independent ambulation by the time of acute hospital discharge.

The vast majority of patients sat out of bed during their acute care stay (96%), of which 65% achieved this milestone during the ICU admission. This finding is consistent with Bahadur et al; [15] who reported 63% of their cohort sat out of bed during their ICU stay. Our data also demonstrate that 22% of patients had stood and 8% had walked at the time of discharge from the ICU agrees with the study by van der Schaaf et al, [18] who reported that 40% of those who had been ventilated for at least 48 hours were completely dependent during their first week on the general hospital wards. It does however, contrast with the data presented by Schwieckert et al, [13] who described 51% and 27% as standing and walking at the time of discharge from the ICU, respectively. Further, our data indicate that the average patient stood for the first time five days after discharge from ICU whereas Schwieckert et al, [13] described patients as first standing within one week of being intubated. There are three reasons underpinning these disparities. First, although similar in APACHE II scores, the average patient in our study was sedated for longer than the survivors in the study by Schwieckert et al, [13] being 7 vs. < 5 days. This was coupled with a longer duration of MV in our sample (13 vs. < 6 days). These differences suggest that the patients in our sample had a more complex ICU admission and perhaps also reflect a disparity in sedation practice. Second, our sample comprised 36% of patients admitted with a neurological insult. This is in accordance with our hospital being the principal centre for neurosurgery within the state. Compared with patients admitted with other conditions, these patients are often characterized by muscle weakness of neurological origin and reduced consciousness, both of which often preclude early standing and walking. Notably, patients with raised intracranial pressures were excluded from participating in the study by Schwieckert et al [13]. Third, 29% of our sample was discharged from the ICU without being fully liberated from MV. This reflects our hospital having a

weaning-specific ward that accepts patients requiring high levels of ongoing ventilatory support including bi-level positive airways pressure via trachestomy. Although not explicitly stated by Schwieckert et al [13]most hospitals do not have the capacity to discharge patients from the ICU until they are fully liberated from MV. Keeping patients in the ICU throughout the weaning period offers greater opportunity for them to achieve functional milestones such as standing and walking in this environment.

An impressive finding of our study was the impact a delay in standing had on the odds of not being able to ambulate independently at the time of discharge. In those who first achieved standing between 30 and 60 days from ICU admission, the odds of not being able to ambulate independently at the time of discharge increased five-fold. Delaying standing from more than 60 days increased these odds 28-fold. These data suggest that rehabilitation, which aims to facilitate weight bearing as soon as possible following admission to the ICU, may positively impact on functional outcomes, even amongst a group of patients characterized by a preponderance of neurological injury and a prolonged and difficult ICU course. However, it is likely that time at which specific functional milestones can be achieved in these patients is, at least in part, constrained by the morbidity and management strategies associated with the disease or injury.

Limitations

We accept that the conclusions made in this study are limited by retrospective data collection. Notwithstanding this consideration, great care was taken to exhaustively review all medical records. Further, the investigators responsible for undertaking data extraction were both physiotherapists with PhDs and extensive clinical experience in the ICU setting. Although data summarised in Table 1 provides insight regarding some of the barriers to early mobilisation in our sample, it was beyond the scope of this study to determine all barriers in this population.

CONCLUSIONS

To our knowledge, this is the first study to explore ambulation status at the time of discharge from ICU in all patients who required MV for a prolonged period, regardless of the reason for admission. Following a period of prolonged MV, less than 50% of patients were able to ambulate independently at the time of hospital discharge. Of those who could, 39% required a gait aid to achieve independence. Even among those patients characterized by prolonged MV and preponderance of neurological injury, a delay in standing following ICU admission was an important predictor of the capacity to ambulate at the time of hospital discharge.

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Figure 1: Selection process for patients included in this study

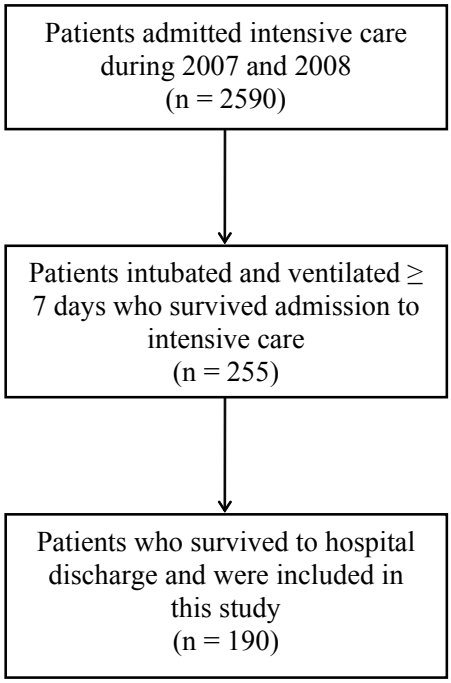

Table 1: Sample characteristics (n = 190)

	n (%)
Causes of admission to intensive care	
Trauma including traumatic brain injury	38 (20)
Trauma without traumatic brain injury	5 (3)
Neurological insult other than traumatic brain injury	30 (16)
From surgery, not related to trauma or neurosurgery	31 (16)
Medical cause	75 (39)
Attempted suicide including pharmacological overdose	11 (6)
Management strategies within the intensive care unit	
Required tracheostomy	143 (75)
Smoking history (current or ex-smoker)	100 (53)
Required a femoral line	70 (37)
Required haemodialysis	54 (28)
Documented evidence of ARDS	45 (24)
Required nitric oxide	18 (9)
Required intra-aortic balloon pump	15 (8)
Required extra-corporeal membrane oxygenation	1 (0.5)

ARDS: acute respiratory distress syndrome

Table 2: Ambulation status, pre-admission living arrangements and discharge destination

Ambulation status		
	Prior to admission n (%)	**At hospital discharge n (%)**
Independent without a gait aid	180 (95)	54 (28)
Ambulating independently using a gait aid	9 (4)	35 (18)
Ambulating with supervision	-	15 (8)
Ambulating with a gait aid and assistance	-	33 (17)
Ambulating with assistance without a gait aid	-	14 (7)
Standing or standing transfers only	-	12 (6)
Unable to stand	1 (0.5)	27 (14)

Pre-admission living arrangements and discharge destination		
	Prior to admission n (%)	**At hospital discharge n (%)**
Home, completely independent	151 (79)	4 (2)
Home, requires assistance for some activities	37 (19)	72 (38)
Rehabilitation facility	-	82 (43)
Supported residential care, including nursing home	1 (0.5)	6 (3)
Other, including a different acute care facility	1 (0.5)	26 (14)

Table 3: Characteristics of patients grouped according to whether or not they could ambulate independently at the time of discharge from acute care

	Able to ambulate independently with or without a gait aid (n = 89)			Unable to ambulate independently with or without a gait aid (n = 101)			
	n available for analysis	**mean ± SD median [IQR]**	**range**	**n available for analysis**	**mean ± SD median [IQR]**	**range**	**p-value**
Age (years)	89	52 ± 18	15 to 83	101	51 ± 19	15 to 82	0.72
Weight (kg)	88	90.8 ± 25.1	45.5 to 181.0	100	85.5 ± 23.7	52.1 to 178.3	0.14
Charlson co-morbidity index (adjusted for age)	89	0 [4]	0 to 11	101	0 [3]	0 to 9	0.09
APACHE II score	89	21 ± 8	7 to 45	99	20 ± 7	8 to 37	0.24
Length of stay: ICU (days)	89	13 [9]	8 to 59	101	15 [13]	8 to 98	0.03
Length of stay: hospital (days)	89	36 [24]	11 to 163	101	53 [41]	11 to 344	<0.001
Duration of mechanical ventilation in ICU (days)	89	12 [9]	7 to 59	101	13 [12]	7 to 96	0.04
Duration of sedation (days)	89	7 [4]	0 to 25	101	7 [6]	1 to 28	0.86
Duration of inotropic support (days)	89	4 [4]	0 to 12	101	3 [5]	0 to 16	0.87

Time between ICU admission and when the patient first sat out of bed (days)	87*	10 [6]	3 to 96	96	14 [10]	4 to 63	<0.001
Time between ICU admission and when the patient first stood (days)	89	17 [11]	4 to 140	74	25 [28]	7 to 138	<0.001
Time between ICU admission and when the patient first walked (days)	89	20 [14]	9 to 145	66	31 [31]	9 to 175	<0.001

APACHE: Acute Physiology and Chronic Health Evaluation; ICU: intensive care unit: IQR: interquartile range; *: two patients were unable to sit out of bed due to sacral wounds.