Abstract

Objectives:

The objectives of this study were to develop a scale for measuring the highest level of mobility in adult ICU patients and to assess its feasibility and inter-rater reliability.

Background:

Growing evidence supports the feasibility, safety and efficacy of early mobilization in the intensive care unit (ICU). However, there are no adequately validated tools to quickly, easily, and reliably describe the mobility milestones of adult patients in ICU. Identifying or developing such a tool is a priority for evaluating mobility and rehabilitation activities for research and clinical care purposes.

Methods:

This study was performed at two ICUs in Australia. Thirty ICU nursing, and physiotherapy staff assessed the feasibility of the 'ICU Mobility Scale' (IMS) using a 10-item questionnaire. The inter-rater reliability of the IMS was assessed by 2 junior physical therapists, 2 senior physical therapists, and 16 nursing staff in 100 consecutive medical, surgical or trauma ICU patients.

Results:

An 11 point IMS scale was developed based on multidisciplinary input. Participating clinicians reported that the scale was clear, with 95% of respondents reporting that it took <1 minute to complete. The junior and senior physical therapists showed the highest inter-rater reliability with a weighted Kappa (95% confidence interval) of 0.83 (0.76-0.90), while the senior physical therapists and nurses and the junior physical therapists and nurses had a weighted Kappa of 0.72 (0.61-0.83) and 0.69 (0.56-0.81) respectively.

Conclusion:

The IMS is a feasible tool with strong inter-rater reliability for measuring the maximum level of mobility of adult patients in the ICU.

Abstract word count: 248 words

Key words: Critical care, early mobilization, rehabilitation, mechanical ventilation

Introduction

Early mobilization is a part of the rehabilitation process of patients in the intensive care unit (ICU) and is increasingly advocated for the prevention and management of ICU-acquired weakness (ICUAW) and related impairment of physical function[1-4]. Early mobilization is the process of improving a patients functional mobility, such as rolling, sitting, standing and walking, and has been used to reduce duration of mechanical ventilation, ICU and hospital length of stay and to improve functional recovery in ICU survivors[5,6]. This emphasis has required a cultural shift from providing deep sedation and bed rest in the ICU, to having a more awake and active patient[7-9]. However, there is no gold standard in the ICU describing intensive care patients' level of mobility that can be used at the bedside by any member of the ICU multidisciplinary team in a quick, easy and reliable manner [10,11].

Early mobilization in the ICU can be provided by nursing staff or physical therapists; however physical therapists are not always employed in intensive care units internationally. Any measure of mobility milestones in the ICU must be feasible, valid and reliable across both nursing and physical therapy disciplines. A previous survey suggested that few physical therapists use any specific instrument to evaluate mobility in ICU[12]. These findings may be because many other existing measures, such as the six minute walk test, were developed and validated outside of the ICU setting and are difficult to perform in the ICU[11]. No previous data report the reliability and feasibility of nursing and physical therapy staff to report activities of mobilization in ICU.

Several studies have reported mobility milestones, such as sitting, standing or walking, as an important indication of patient physical function in ICU[7,8,13]. They have not reported the level of assistance required to achieve the mobility milestone and they have not reported the same milestones. A recent systematic review described measures of physical function used in studies investigating early mobilization in the ICU[11]. The ability to perform activities of mobility, or mobility milestones, was the most common end-point reported in these studies. However, there was no consensus on the activities that should be included in measures of mobility in the ICU, or reports of the feasibility or inter-rater reliability of such measures[11]. No reliable scale or measure was found in the published or unpublished literature that could assess early mobilization in the ICU. One unpublished scale was identified that was used as part of the Critical Care Physical Medicine and Rehabilitation Program at Johns Hopkins

Hospital (Baltimore, USA) but it included other criteria that were not mobility items, such as respiratory care, and it had not been tested for reliability.

The ability to quickly, easily and reliably report the highest level of mobilization in the ICU may be important for both research purposes and safe clinical practice. It is plausible that patients who have a higher level of physical function at ICU discharge may have reduced hospital length of stay and improved functional recovery after critical illness[6]. The objectives of this study was to develop an ICU Mobility Scale (IMS), using commonly reported mobility milestones from published and unpublished literature, to report the highest level of patient mobility in ICU. The criteria for the scale was that it was feasible for use by the nursing and physical therapy staff at the bedside, and that it had good inter-rater reliability to measure the highest level of mobilization of adult ICU patients.

Methods

Design and Setting

This prospective observational study was performed at two quaternary ICUs in Melbourne, Australia in September 2012. Both were closed units, one was a 20 bed mixed medical/surgical unit and the other was a 35 bed mixed medical/surgical/trauma unit. The study was approved by the ethics committees of Austin Health and Alfred Health. Patient consent was waived as the study was observational with no identifying data recorded, while verbal consent was gained from the nurses and physical therapists participating in the study. The study was divided into three parts: part one was the development of the IMS, part two was the feasibility testing of the IMS and part three was the inter-rater reliability testing.

Participants:

Inclusion criteria

The participants who developed the scale were clinicians with more than 10 years' experience in ICU who were involved in research projects about ICU mobilization, including 5 physicians, 8 physical therapists and 2 nurses as part of the Australian and New Zealand Intensive Care Society Clinical Trials Group program of research on ICU mobilization and with two international experts collaborating from Johns Hopkins Hospital, USA. Participants involved in the feasibility testing included a convenience sample of 30 multi-disciplinary ICU clinicians (15 physical therapists and 15 nurses) from two Australian hospitals who were available to complete a survey on the day of feasibility testing.

Twenty clinicians, who were the nurses and physical therapists involved in direct care of a patient on the day of the inter-rater reliability testing, volunteered to participate. In the ICUs involved in the study, the staff at the bedside involved in mobility activities included the bedside nurse, a junior and a senior physiotherapist. Therefore, for each measurement of inter-rater reliability, three clinicians were included and rated the same patient using the IMS; one senior physical therapist (≥ 2 years ICU experience), one junior physical therapist (≤ 2 years' experience) and one nurse (≥ 2 years' experience). Consecutive patients from the mixed medical-surgical-trauma ICU from two different hospitals in Australia, without any exclusion criteria, were assessed using the IMS to determine the inter-rater reliability.

Developing the ICU Mobility Scale (IMS)

A multi-disciplinary group of critical care clinicians, including 5 physicians, 8 physical therapists and 2 nurses from the Australian and New Zealand Intensive Care Society Clinical Trials Group and Johns Hopkins Hospital, Baltimore with expertise in scale development and already conducting studies in ICU rehabilitation, was recruited to develop a scale for measuring mobility in the ICU. The group agreed that the scale needed to meet a number of objectives[14]: (1) to be useable by all members of the multidisciplinary ICU team, (2) to have content validity[15] (i.e. to measure what it is intended to measure), (3) to be feasible[16] (i.e., quick and easy to administer and record), and (4) to have high inter-rater reliability across physical therapists and nurses for a wide-spectrum of adult ICU patients.

The ICU mobility scale (IMS) was developed by the multidisciplinary group using both levels of mobilization published from existing studies of early mobilization in the ICU [5,7,8,13] and the unpublished scale from Johns Hopkins Hospital (as previously described). There were several differences between the IMS and the other reported scales, including more levels of mobilization and the previous scales did not report the level of assistance required for ambulation. For example, the other scales would simply report ability to ambulate, without clarifying whether the patient required assistance of one person, two people or a gait aid.

The IMS was then presented at the Fifth International Meeting of Physical Medicine & Rehabilitation (PM&R) in the Critically Ill in San Francisco on May 19, 2012. At this meeting, the IMS was discussed and one additional item was added based on external expert input from experienced ICU and rehabilitation clinicians and researchers. This included one additional category of ambulation to best represent the activities of mobilization undertaken

in ICU by nursing and physical therapy staff, to obtain a final 11-level IMS (Table 1). For the current study, the final 11-level IMS was internationally circulated, via email and website posting (www.mobilization-network.org) to more than 100 additional ICU and rehabilitation clinicians and researchers specifically interested in ICU rehabilitation, for critical review and comment. No additional changes were suggested. The IMS was then pilot tested in the ICU at two different hospitals in Australia to determine feasibility and inter-rater reliability.

Feasibility of the IMS

A convenience sample of 30 multi-disciplinary ICU clinicians (15 physical therapists and 15 nurses) across 2 hospitals in Australia, with varying levels of clinical experience, were asked to use the IMS in ICU on a single day, and then administered a 10-item survey to assess the feasibility of the IMS (Table 2). The survey tool included measures that were based on published guidelines for questionnaires[17] and included questions about the clarity of the scale and its definitions, relevance, and time requirement for administration and recording (Table 2). The survey was pilot tested for clarity in a group of five clinicians prior to its administration to the larger group.

Inter-rater reliability testing of the IMS

One nurse, one senior physical therapist and one junior physical therapist from the sample of 20 clinicians available, assessed consecutive patients from the medical, surgical or trauma ICU using the IMS. The sample size for the inter-rater reliability of the IMS was determined based on an observed difference in weighted Kappa between any two observers of 0.10. (0.8 vs 0.7) Extrapolating from Stratford [18] it was anticipated that to have an 80% power with a two sided p-value of 0.05 would require a sample size of 100. These calculations were further validated by the direct comparison of rater scores. Based on an estimated standard deviation in the difference between two raters of 2 points (pilot data), with 86 patients, this study had a >95% power to detect a one unit difference with a two sided p-value of < 0.05. In accordance with Lehmann [22] the sample size was further inflated by 15% to account for non-normality of this ordinal scale resulting in a total of 100 patients.

Each patient was assessed by the three clinicians within 30 minutes of each other on the same day, in order to determine the inter-rater reliability. Consistent with previous studies, the

participating clinicians were asked to score the maximum level of mobility for the patient in the previous 24 hours[19]. Each clinician could select only one category. Demographic data for the included patients are shown in Table 3.

The three clinicians used to score the IMS were selected on the day of data collection from the ICUs of two separate hospitals to participate in the study. Each participating clinician was an ICU staff member involved in direct patient care, including mobilizing patients, and additionally some had research training (four nurses and two senior physical therapists), as this tool was intended for both routine bedside recording and research purposes. The clinicians were sixteen nurses who were rostered onto the ICU for ward service on the days of data collection with at least two years' experience in ICU, two senior ICU physical therapists and two ICU junior physical therapists. For the purpose of this study physicians were not asked to score patients using the IMS as it was agreed that they would simply ask the nurse's or the physical therapist's IMS during the ward round. The clinicians were provided the IMS and the short written definition of each level of the scale (Table 1) prior to assessing the patient.

Data collection was completed at 4pm for the preceding 24 hours. To reflect real world clinical practice, there were no restrictions on how information for completing the scale was gained, including completion based on direct clinical experience with the patient, written clinical notes and verbal communication with other clinical staff. Clinicians involved in the inter-rater reliability testing were blinded to the other clinicians' scores of the IMS.

Statistical Analysis

To evaluate inter-rater reliability among all 3 evaluators of each IMS assessment, the Intraclass Correlation ICC(2,1) was calculated in accordance with Shrout and Fleiss [20] and reported with a 95% confidence interval. Qualitative interpretation of the ICC was as follows: 0-0.2 indicates *poor* agreement: 0.3-0.4 *fair* agreement; 0.5-0.6 moderate agreement; 0.7-0.8 *strong* agreement; and >0.8 indicates *almost perfect* agreement. Pairwise comparisons between raters were evaluated using the Spearman correlation and the weighted Kappa statistic. Weighting for the Kappa statistic was done as follows: weight of 1 was assigned for perfect agreement and 0 for the largest possible disagreement, with weights of all other misclassifications determined linearly[21]. Inter-rater reliability was qualitatively interpreted as *excellent* for a weighted Kappa >0.8, *strong* for a weighted Kappa>0.7 and *good* for a

weighted Kappa>0.6 [22]. Wilcoxon sign rank tests were used to evaluate the statistical significance of differences in scores between pairs. Statistical analysis was performed using SAS version 9.2 (SAS Institute Inc., Cary, NC, USA). A two sided p value of < 0.05 was considered to be statistically significant.

Results

Table 2 describes results of the survey evaluating the feasibility of the IMS. The IMS was able to be used quickly by participating clinicians with 90% of them reporting that they perceived it would take <1 minute to complete and that there were adequate definitions, without items that were unnecessary or repetitive. All participants (100%) reported the scale to be unambiguous. More than 90% of the participants responded that it was an appropriate length. Eighty percent of participants replied that the scale did not have sections that were irrelevant or superfluous. There were some aspects of the IMS that were considered irrelevant, superfluous or misleading by 15% the survey respondents. These specific comments were related to the need for clearer definition of active mobilization, particularly with the use of equipment such as a tilt-table or a standing lifter.

The participating nurses all had more than 2 years' experience working in ICU (range 2-40 years). The junior physical therapists had less than two years' experience working in ICU (range 3 months – 23 months) while the senior physical therapists had more than 2 years' experience in ICU (range 2-8 years).

Table 3 describes the demographic data of the 100 patients who were scored using the IMS. The mean age of the patients was 58 years and 62% were female. The mean ±standard deviation severity of illness score measured using APACHE II was 19±7. The patients were a mix of medical (38%), trauma (23%) and surgical (39%). For each of the 100 patients, a nurse, a senior physical therapists and a junior physical therapist attempted to rate the mobility of the patient using the IMS; however, on three separate occasions a patient was unavailable to be scored by the nurse and could not be included in analysis.

The median (interquartile range) of the IMS reported by participating nurses, senior physical therapists and junior physical therapists was 0.5 (0 - 4.5), 1 (0 - 4) and 1 (0 - 4), respectively. The range of scores among each of the 3 clinician groups was 0 to 10. The frequency distribution was skewed to the lower end of the scale, reflecting the low level of mobilization

activities in ICU. As a result, no senior physical therapist scored the IMS at level 7, no nurse scored the IMS at level 9 and no junior physical therapist scored the IMS at level 10.

The overall intraclass correlation (95% confident interval) between raters was excellent [0.80 (0.75-0.84)]. Table 4 shows agreement for the IMS between (a) senior and junior physical therapists with almost perfect agreement (b) senior physical therapists and nurses with strong agreement and (c) junior physical therapists and nurses with moderate agreement There were no statistically significant differences in scores between any of the groups rating the scale (Table 4) and the scores were not consistently higher or lower for any particular group. To assess for individual differences between clinicians, a subgroup of 20 patients that were assessed by the same three clinicians (one nurse, one senior physio and one junior physio) thus facilitating specific measures of inter-rater reliability. With this sub population the weighted Kappa scores were as follows senior and junior physical therapist Kappa 0.84 (0.75-0.93), senior physical therapist and nurse Kappa 0.77 (0.66-0.87), junior physical therapist and nurse Kappa 0.90 (0.82-0.99).

Discussion

We aimed to identify a scale for measuring the highest level of patient mobility in the ICU, and to assess its feasibility and inter-rater reliability. The IMS was feasible, generally taking less than 1 minute to complete, and was able to be used by a wide range of ICU nurses and physical therapists based on simple written definitions, without prior training or use of the scale. There was excellent agreement of the IMS scores between physical therapists and strong agreement between nursing staff and physical therapists.

Currently there are few existing measures for describing patient mobility levels in the ICU[10,11]. Mobility milestones have been described by several authors when reporting results of studies of ICU mobilization and rehabilitation, but these milestones have not been used in a standardized manner[23-26].

With pre-defined objectives, we used a pragmatic approach to select and modify a pre-existing scale to create the IMS. The 11 levels of the IMS are based on activities that can reasonably be achieved across the spectrum of recovery of patients while in the ICU. Moreover the reliability assessment was conducted at two large intensive care units with a

varied clinical case mix, including surgical, medical and trauma patients, and included nurses and junior and senior physical therapists. Despite the busy ICU environment, the IMS was administered with ease. The inter-rater agreement in the scale was excellent between physical therapists and good between nursing staff and physical therapists. The reduced agreement between the different professions may reflect differing terminology used to describe mobilization, the lack of time for reading specific definitions for using the IMS, or the lack of documentation in the clinical notes about mobilization episodes. It is possible that the agreement would improve with specific training and further clarification of definitions used for mobility levels in the IMS, particularly regarding active versus passive sitting out of bed and standing.

Other measures of physical function that test a patient's strength[27] or physical ability have been described[10,28-30], particularly by physical therapists as part of their rehabilitation practice. However this is the first scale that has reported feasibility and inter-rater reliability for measuring the highest daily level of mobility in ICU patients. The multidisciplinary nature of use of this scale is important for the shared responsibility of identifying and promoting early activity in the ICU[31,32].

There are potential limitations of this study. First, the search for unpublished scales could not be done systematically, but there was wide consultation and solicitation among a large international group of people via the Fifth International Meeting of Physical Medicine & Rehabilitation in the Critically Ill in San Francisco on May 19, 2012, the ICU mobilization website (www.mobilization-network.org) and an email list of ICU rehabilitation clinicians and researchers. Second, this scale may be limited as it is ordinal; hence, we do not know, for the purposes of analysis, whether the distance between each of the levels of the scale is equal, or if the ordering of levels within the scale in terms of functional ability is accurate. Moreover, the frequency distribution of the IMS was not normally distributed, in fact the maximum level of mobility was not achieved within this cohort of ICU patients, and therefore any future study that uses this endpoint may be limited to non-parametric methods of analysis. A future test of this scale should examine sensitivity to change over time. The IMS was based on expert opinion and requires further validation. The scale was not tested for inter-rater reliability in other professions involved in ICU care, such as the physicians, or between different years of ICU experience in professions other than physical therapy. Also, the IMS was used by physiotherapists more commonly than the nursing staff, which may

have resulted in a practice effect. Finally, it is unclear whether this scale is associated with any recognized clinical outcome, such as physical function at hospital discharge[6,33]. However, this is the first paper to standardize the use of important mobility milestones for both clinical and research purposes in ICU.

We propose use of the IMS to standardize measuring and reporting of a patients' highest level of mobilization in the ICU, while further psychometric evaluation regarding validity and responsiveness are explored. Future research directions include feasibility testing in larger cohorts of ICU patients in order to determine the time taken to complete the IMS (less than five minutes or less than one minute), international comparisons of large ICU patient cohorts using the IMS to determine the highest level of mobilization in ICU and to compare the IMS to longer term outcome such as return to previous levels of physical function[6].

In conclusion, the IMS is feasible with strong inter-rater reliability for recording the maximum daily level of mobility of patients in the ICU by physical therapists and nurses. This simple scale of mobility milestones will not replace other tests of physical function, but may assist as a daily record of mobility for both clinical and research purposes in order to allow greater standardization and comparability between ICUs. The validation of this measure is an important area of future research before implementation as a standard measure of mobility in ICU.

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Table 1. ICU Mobility Scale

	Classification	Definition
0	Nothing (lying in bed)	Passively rolled or passively exercised by staff, but not actively moving
1	Sitting in bed, exercises in bed	Any activity in bed, including rolling, bridging, active exercises, cycle ergometry and active assisted exercises; not moving out of bed or over the edge of the bed
2	Passively moved to chair (no standing)	Hoist, passive lift or slide transfer to the chair, with no standing or sitting on the edge of the bed
3	Sitting over edge of bed	May be assisted by staff, but involves actively sitting over the side of the bed with some trunk control
4	Standing	Weight bearing through the feet in the standing position, with or without assistance. This may include use of a standing lifter device or tilt table.
5	Transferring bed to chair	Able to step or shuffle through standing to the chair. This involves actively transferring weight from one leg to another to move to the chair. If the patient has been stood with the assistance of a medical device, they must step to the chair (not included if the patient is wheeled in a standing lifter device.)
6	Marching on spot (at bedside)	Able to walk on the spot by lifting alternate feet (must be able to step at least 4 times, twice on each foot), with or without assistance
7	Walking with assistance of 2 or more people	Walking away from the bed/chair by at least 5 metres (5 yards) assisted by 2 or more people
8	Walking with assistance of 1 person	Walking away from the bed/chair by at least 5 metres (5 yards) assisted by 1 person
9	Walking independently with a gait aid	Walking away from the bed/chair by at least 5 metres (5 yards) with a gait aid, but no assistance from another person. In a wheelchair bound person, this activity level includes wheeling the chair independently 5 metres (5 years) away from the bed/chair
10	Walking independently without a gait aid	Walking away from the bed/chair by at least 5 metres (5 yards) without a gait aid or assistance from another person.

Table

Table 2. Feasibility survey of the ICU Mobility Scale (IMS) (N = 30 respondents)

	Yes (%)	No (%)	Unclear (%)
Is the IMS clear and unambiguous?	100	0	0
Did the IMS take less than 1 minute to complete?	90	10	0
Did the IMS take less than 5 minutes to complete?	100	0	0
Does the IMS indicate what the scale is about and the overall purpose?	90	0	10
Are there adequate definitions of the IMS, with examples?	90	6	4
Are any levels of the scale irrelevant, misleading or superfluous?	15	75	10
Are any levels of the scale offensive or otherwise inappropriate?	0	97	3
Will respondents know the answer to the question?	93	0	7
Are any items unnecessary or repetitive?	10	90	0
Is it an appropriate length?	97	0	3

Table 3. Demographic data of included patients

Demographics	**N=100**
Age in years (mean±SD)	58±17
Female (%)	62
APACHE II (mean±SD)	19±7
APACHE III (mean±SD)	68±25
Medical (%)	38
Surgical (%)	39
Trauma (%)	23
Mechanically ventilated (%)	70
Tracheostomy present (%)	20
Mechanical ventilation duration, median (IQR) days	185 (116 – 622)

Table 4 Inter-rater reliability of the ICU mobility scale (IMS)

Comparison Groups	Weighted Kappa (95%CI)	Spearman rho (95%CI)	P-value for difference in score between clinicians
Senior vs. Junior physiotherapist n=97*	0.83 (0.76-0.90)	0.91 (0.87-0.94)	0.31
Nurse vs. Senior physiotherapist n=95*	0.72 (0.61-0.83)	0.80 (0.70-0.95)	0.60
Nurse vs. Junior physiotherapist n=97*	0.69 (0.56-0.81)	0.77 (0.68-0.84)	0.65

*Missing data as the patient was unavailable for assessment in ICU