Early Mobilization in the Intensive Care Unit: A Systematic Review

Joseph Adler, PT, DPT, CCS[1]
Daniel Malone, PhD, MPT, CCS[2]

[1]Good Shepherd Penn Partners at The Hospital of the University of Pennsylvania, Philadelphia, PA
[2]Physical Therapy Program, Department of Physical Medicine and Rehabilitation; University of Colorado; Denver, CO

ABSTRACT

Purpose: The purpose of this review is to evaluate the literature related to mobilization of the critically ill patient with an emphasis on functional outcomes and patient safety. **Methods:** We searched the electronic databases of PubMed, CINAHL, Medline (Ovid), and The Cochrane Library for a period spanning 2000-2011. Articles used in this review included randomized and nonrandomized clinical trials, prospective and retrospective analyses, and case series in peer-reviewed journals. Sackett's Levels of Evidence were used to classify the current literature to evaluate the strength of the outcomes reported. **Results:** Fifteen studies met inclusion criteria and were reviewed. According to Sackett's Levels of Evidence, 9 studies were level 4 evidence, one study was level 3, 4 studies were level 2, and one study was level one evidence. Ten studies pertained to patient safety/feasibility and 10 studies pertained to functional outcomes with 5 fitting into both categories. **Conclusion:** A search of the scientific literature revealed a limited number of studies that examined the mobilization of critically ill patients in the intensive care unit. However, literature that does exist supports early mobilization and physical therapy as a safe and effective intervention that can have a significant impact on functional outcomes.

Key Words: mobilization, exercise, intensive care unit, critical illness, physical therapy

INTRODUCTION

The early mobilization of patients in the intensive care unit (ICU) has received considerable attention in clinical and scientific literature over the past several years.[1-3] A wide range of published reports has attempted to study the effects of mobilization and physical therapy on multiple factors including patient safety, ambulation capacity, muscle strength, functional outcomes such as activities of daily living, duration of mechanical ventilation, ICU length of stay, hospital length of stay, and mortality.

There are inherent complications to mobilizing critically ill patients that appear straightforward but are not well established. These apparent complications include, but are not limited to: tenuous hemodynamic status, severe weakness, multiple central catheters and life supporting monitors, artificial airways and operational factors such as variable rehabilitation work practices.[4-7]

Studies have demonstrated that survivors of critical illness have impaired exercise capacity and persistent weakness, suboptimal quality of life, enduring neuropsychological impairments and high costs of health care utilization.[8-12] It has been hypothesized that ICU-based interventions may play a role in reducing these ongoing physical and neuropsychological impairments in ICU survivors in both the short- and long-term, highlighting the importance of studying this population.[12]

When patients require admission or readmission to the ICU, a period of enforced bed rest generally ensues. Despite knowledge of the deleterious effects of bed rest on multiple body systems,[13-16] the ICU is a complicated and difficult environment in which to mobilize the critically ill.[1,17] Multiple life-sustaining catheters and monitors, sedative medication used to calm agitation or reduce energy expenditure, impaired levels of alertness from medications, sleep disturbances, electrolyte imbalances, and tenuous hemodynamic status all are contributing factors that limit mobilization.

As critical care medicine improves and overall mortality decreases, survivors of ICU admissions are realizing greater morbidity. Severe weakness, deficits in self-care and ambulation, poor quality of life, hospital readmission, and death have all been reported in patients up to 5 years after discharge from the ICU.[12,18]

Mobilizing patients in the intensive care environment is not without risk. Catheters and supportive equipment attached to patients can become dislodged and cause injury. Insertion and reinsertion of catheters can increase infection risk and cause unwanted stress and pain for patients and families already stressed by the medical acuity of the ICU. Critically ill patients with physiological derangements can have adverse hemodynamic responses to activity. Patients with limited aerobic capacity may respond to exertional

Address correspondences to: Joe Adler, PT, DPT, CCS, Good Shepherd Penn Partner's at the Hospital of the University of Pennsylvania, Department of Occupational and Physical Therapy, 1st Floor White Building, 3400 Spruce Street, Philadelphia, PA 19104 (joe.adler@uphs.upenn.edu).

stress with exaggerated heart rate and blood pressure responses or conversely may not have enough physiologic reserve to meet even the seemingly simple task of sitting on the edge of the bed.

Although the frequency of published reports related to mobilizing critically ill patients is increasing, the number of controlled, randomized trials is few. The purpose of this review was to examine the literature and characterize the clinical benefits of mobilizing critically ill patients found predominantly in the ICU, specifically related to safety and functional outcomes.

METHODS

Literature Search

The electronic databases of PubMed, CINAHL/Nursing, Medline (Ovid) and the Cochrane Library were searched as noted in Figure 1. The key search terms, "mobilization," "exercise," and "physical therapy" were combined with "intensive care unit" and "critical illness." Reference lists of review articles and original publications were manually reviewed supplementing the electronic search to ensure that the database searches were comprehensive.

Study Selection Criteria

Articles included in this review were: prospective randomized trials, prospective cohort studies, retrospective analyses, and case series. We further limited our inclusion to articles that focused on adults that were published in English between January 1, 2000 and June 1, 2011 to capture the most recently published work. Studies were evaluated to determine fit to the inclusion criteria by review of the title, and the list of potential articles was further sorted by reviewing abstracts by the primary author (JA). Studies were excluded if they were review articles, only studied nonmobility interventions, and/or described programs or protocols designed to promote early mobilization. If relevancy was questioned, both authors then collaborated on the final decision for inclusion.

Levels of Evidence

Sackett's Levels of Evidence were used to rate the strength of the research[19] process where research was ranked from strongest to weakest using a 5 point grading system as outlined in Table 1. The authors (DM and JA) collaborated equally on scoring.

Table 1. Sackett's Levels of Evidence

1A	Systematic Review of Randomized Controlled Trials (RCTs)
1B	RCTs with Narrow Confidence Interval
1C	All or None Case Series
2A	Systematic Review Cohort Studies
2B	Cohort Study/Low Quality RCT
2C	Outcomes Research
3A	Systematic Review of Case-Controlled Studies
3B	Case-controlled Study
4	Case Series, Poor Cohort Case Controlled
5	Expert Opinion

Adapted from Levels of Evidence. Oxford Centre for Evivdence-based Medicine - Levels of Evidence (March 2009) Website. Available at www.cebm.net. Accessed September 26, 2011.

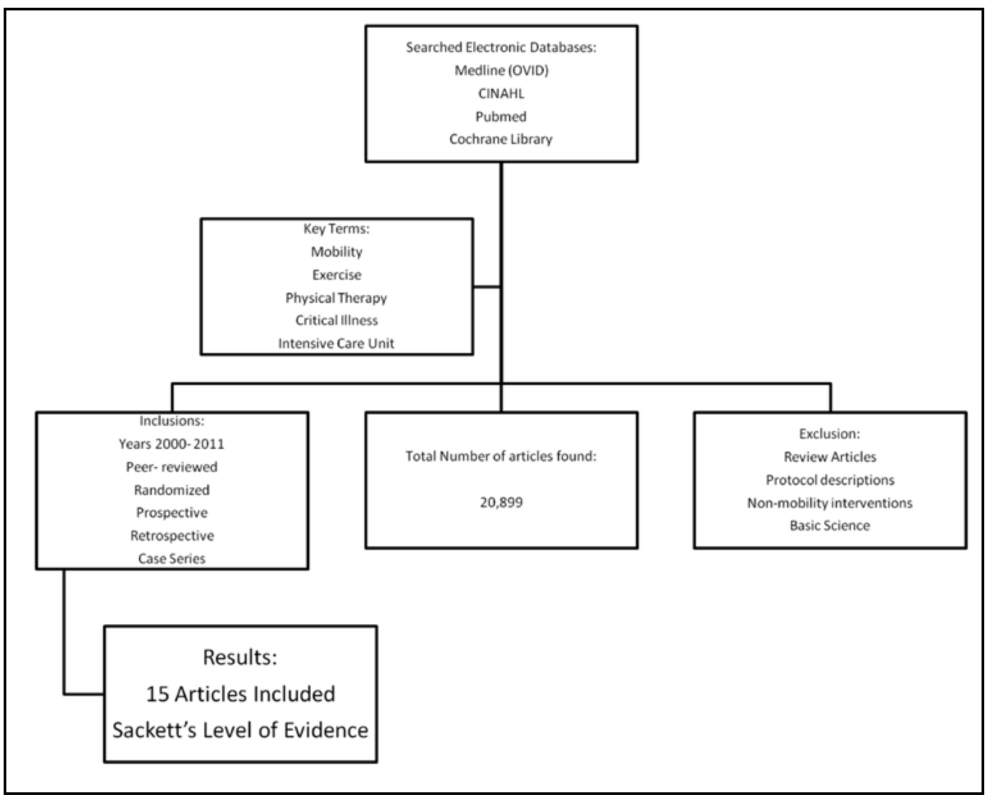

Figure 1. Search algorithm.

RESULTS

Fifteen studies were included in this review and submitted to analysis. Many outcomes were reported in the mobilization of critically ill patients and included a wide range of data. The studies were categorized into two groups based on the outcome addressed: safety and functional outcomes. Functional outcomes were further subdivided into one of 3 areas: muscle strength; quality of life/patient symptoms, and mobility. Some studies overlapped multiple categories. Of the studies reviewed, 4 reported on muscle strength, two on quality of life, and 13 on functional mobility.

Studies included both prospective and retrospective design while randomization occurred in just 3 studies.[20-22] The randomization in Chiang et al's study[22] occurred in a postintensive care environment. Ten studies examined cohort populations or samples of convenience. Eleven of those were prospective.[4,20-29] Four studies were

Table 2. Safety and ICU Mobilization

Study	Study Design (N= subjects)	Sackett's Levels of Evidence	Physical Therapy Interventions	Safety profile	Other notable findings
Stiller K. 2004[27]	Prospective One-group pretest-posttest design N= 160 total patients with 31 receiving mobilization	4	Functional mobility • Supine-to-sit • Sitting edge of bed • Standing • Transfers • Ambulation	69 mobilization sessions with 31 patients (MV = 7 patients (23%)): 3 events (4%) during PT treatments (2 patients on MV) • desaturation (≤ 88%) responsive to increased F_IO_2 **Overall, no serious adverse medical consequences**	• Study highlights the physiologic responses (HR, BP, SpO_2) and patient safety associated with mobilization • Paper "reintroduces" an algorithm for safe patient handling pertaining to the acute care/ ICU settings • Only 31 of 160 of patients (19%) were mobilized following the screening process
Zafiropoulos B. 2004[29]	Prospective One-group pretest-posttest design N=17	4	Patients participated in progressive mobilization from supine> sitting> standing> marching x 1 minute for each activity	• Minute ventilation increased due to increases in tidal volume & respiratory rate with standing with no additional increase with marching; the breathing pattern demonstrated greater upper chest versus abdominal excursion • ABG values were normal • HR/ BP/ MAP increased with mobilization from supine> sitting **Overall, no adverse medical consequences**	• Study emphasized the hemodynamic and respiratory responses in patients who were s/p abdominal surgery ◊ Included measurements of chest wall and abdominal movements to characterize the breathing pattern • No hemodynamic or respiratory compromise • Altered breathing pattern favored upper chest breathing/ ventilation • Pain was not monitored • No control group for comparison
Bailey P. 2007[23]	Prospective One-group pretest-posttest design N=103 patients	4	Twice daily PT/ activity sessions Functional Mobility • Supine-to-sit • Sitting edge of bed • Standing • Transfers • Ambulation F_IO_2 was increase 0.2 prior to sessions	1449 PT/ activity sessions: 14 events (<1%) occurred during PT sessions: • falls to knees (x5) • desaturation < 80% (x3) • SBP <90 mm (x4) • SBP> 200 mmHg (x1) • Nasogastric tube removal (x1) **Overall, no serious adverse medical consequences**	• Study provides systems review criteria (neurologic/ circulatory/ respiratory) used to screen patients prior to mobilization • Of the approximate 1500 activities performed: ◊ Sit at edge of bed (16%) ◊ OOB (31%) ◊ Ambulate (53%) • Age & co morbidities did not influence ambulatory status
Morris PE. 2008[25]	Prospective Cohort study (N=330; 165 intervention/ protocol; 165 "usual" care")	2B	Mobilization program implemented 7 days/ week by "**mobility team"** consisting of: PT Critical care RN Nursing assistant	• 116 of 135 patients (80%) of protocol patients received PT during hospital stay for approx. 638 total PT sessions • Therapy sessions not initiated if BP/ HR outside of listed inclusion criteria (£ 1.4% of total sessions) **Overall, no serious adverse medical consequences**	• Protocol for mobilization(activity algorithm) and criteria for limiting therapy sessions are well defined • Mobility sessions primarily ended due to patient c/o fatigue without significant change in vital signs
Burtin C. 2009[21]	Prospective RCT (N = 90 enrolled; 67 completed) (36 control; 31 treatment group)	2B	5 days/ week **Both groups received:** Upper extremity ther. ex. Lower extremity ther ex. Functional training. **Treatment group:** Additional cycling session x 20 minutes total, daily	425 total exercise sessions • 16 sessions (<4%) terminated due to desaturation <90% or HTN; • 3 subjects withdrawn: ◊ Achilles tendon rupture (x1) ◊ cardiorespiratory instability (x2)	Achilles tendon rupture could be considered a serious adverse event • injury most likely due to the addition of cycling as a treatment modality • cardio-respiratory instability not well defined in paper.
Schweickert WD. 2009[20]	Prospective RCT (N=104; all patients completed study)	1B	7 days/ week Treatment group: Progressive UE/ LE ther ex.; Trunk control/ balance activities Functional training including ADL's	498 PT/ OT sessions: • 1 desaturation <80% • 1 radial artery line removed • PT/ OT was discontinued during 19 sessions (4%) for perceived patient-ventilator asynchrony **Overall, no adverse medical consequences**	• Protocol for mobilization and criteria for limiting therapy sessions are well defined • Study supports that early PT/ OT is safe and the primary event limiting patient participation in PT/OT was patient-ventilator asynchrony
Pohlman MC. 2010[32]	Retrospective Descriptive study/ case series using data from prior study (see Schweickert above) N= 49 patients	4	As noted above	In patients receiving MV, the primary reasons for missed therapy session • MV asynchrony (<4%) • MAP <65 mm Hg (<1%) • Vasoactive medication (<1%) • Active GIB (<1%) PT/ OT sessions were terminated due to • Desaturation >5% (6%) • HR & MV asynchrony (4%) • Agitation/ discomfort (2%) • Device/ line removal (<1%) **Overall, no adverse medical consequences**	• Early PT/ OT is feasible & safe within 24-48 hours of ICU admission/ MV • PT/OT occurred on 87% of eligible days (n=498 of 570); # of missed session similar between MV and extubated patients • Patients performed more aggressive mobilization as they progressed from MV to extubation • PT/ OT sessions proceeded even though patients had central venous access/ HD catheters; arterial lines; ETT/ tracheostomy tubes • Following extubation, PT/ OT held primarily due to patient refusal (c/o fatigue)
Zanni JM. 2010[4]	Prospective Pilot Project One-group pretest-posttest design (N= 32 eligible; 22 completed study to hospital discharge)	4	Observational report to define patient profiles and therapy services in ICU: • consult & treatment frequency • mobility/ ADL's • ROM/ strength • patient safety	• 50 reviewed PT/ OT session with 19 patients **Overall, no serious adverse medical consequences**	• Study identified common barriers & provides helpful recommendations to implement PT/OT in ICU setting • over half of patients required post-acute rehabilitation following ICU stay • 81% of patients had an episode of delirium

Needham DM. 2010[26]	Prospective Quality Improvement (QI) project Case controlled (N = 57 total (27 pre QI; 30 post QI)	3B	Functional mobility • Supine-to-sit • Sitting edge of bed • Standing • Transfers • Ambulation	Pre-QI: 210 PT/ OT treatment session • No events QI Period: 810 PT/ OT treatment sessions • 4 events (rectal or feeding tube displacement) **Overall, no serious adverse medical consequences**	• Increased number of PT/ OT consults & treatment sessions incorporating more advanced mobilization activities without increased incidence of adverse events
Bourdin G. 2010 [28]	Prospective One-group repeated measurements N=20 consecutive patients	4	Functional mobility training (chair sitting; tilting up with & without arms supported, ambulation)	424 interventions with 13 events (3%) • loss of muscle tone without fall • extubation; desaturation <88%, hypotension **Overall, no serious adverse medical consequences**	• Study emphasizes the physiologic responses associated with a variety of mobilization procedures • Study determined barriers to rehabilitation • Study determined that early mobilization was feasible and safe ◊ Included use of equipment to facilitate upright/ assisted standing

MV=mechanical ventilation, PT=physical therapy, OT=occupational therapy, FiO2=fraction of inspired oxygen , HR= heart rate, HTN=hypertension
BP=blood pressure, SBP=systolic blood pressure, MAP=mean arterial pressure, SPo2=saturation of peripheral oxygen, ICU=intensive care unit
ABG=arterial blood gas, OOB=out of bed, RN=nurse , s/p=status post, c/o=complains of, RCT=randomized controlled trial, Ther ex.=therapeutic exercise, ROM=range of motion, UE/LE=upper/lower extremity, ADL=activity of daily living, GIB=gastrointestinal bleed, HD=hemodialysis , ETT=endotracheal tube

retrospective analyses.[18,30-32] Two of those studied patients in a postacute environment.[30,31]

Safety/Adverse Events

Of all studies reviewed, 10 papers reported data concerning untoward events (eg, line removal, extubation), physiological responses [eg, heart rate (HR), blood pressure (BP), pulse oximetry] and/or need for alteration in medical plan of care (eg, sedative or vasopressor administration). The authors (JA and DM) defined these events as pertaining to patient safety. As noted in Table 2 untoward events occurred in ≤ 4% of total patient interactions. The reviewed studies used specific physiologic responses and patient complaints (see Table 3) to initiate and terminate exercise or activity sessions. Bailey et al[23] consecutively enrolled patients with respiratory failure who required mechanical ventilation for >4 days. There were 14 activity-associated untoward events during 1,449 activity sessions, none of which were deemed serious. In the study by Pohlman and colleagues[32] a descriptive analysis of the intervention arm of the study by Schweickert et al,[20] activity associated adverse events occurred in 16% (80 of 498) of therapy sessions with patients on mechanical ventilation. The authors describe many of the events as “expected physiological changes with exercise.” Examples include a HR increase greater than 20% of baseline (21 of 498 or 4.2 %), and a respiratory rate (RR) greater than 40 breaths per minute (20 of 498 interactions or 4.0%). Activity sessions were halted due to exceeding the predetermined criteria (see Table 3).

Overall, the most commonly cited adverse event was oxygen desaturation. These episodes were of short dura-

Table 3. Criteria for Terminating a PT/ OT Mobilization Session as Summarized from the Literature

Heart Rate: • > 70% APMHR • > 20% decrease in resting HR • < 40 beats/ minute; > 130 beats/ minute • New onset dysrhythmia • New anti-arrhythmia medication • New MI by ECG or cardiac enzymes	Pulse Oximetry/ SpO_2: • > 4% decrease • < 88%- 90%
Blood Pressure: • SBP > 180 mmHg • > 20% decrease in SPB/ DBP; orthostatic hypotension • MAP < 65 mmHg; >110 mmHg • Presences of vasopressor medication; new vasopressor or escalating dose of vasopressor medication	Mechanical Ventilation: • $F_IO_2 \geq 0.60$ • PEEP ≥ 10 • Patient-ventilator asynchrony • MV mode change to assist-control • Tenuous airway
Respiratory Rate: • < 5 breaths/ minute; > 40 breaths/ minute	Alertness/ Agitation and Patient symptoms: • Patient sedation or coma – RASS ≤ -3 • Patient agitation requiring addition or escalation of sedative medication; RASS >2 • Patient c/o intolerable DOE • Patient refusal

PT=physical therapy, OT=occupational therapy, HR= heart rate, RR=respiratory rate
SPo2=saturation of peripheral oxygen, MI=myocardial infarction, ECG=electrocardiogram
BP=blood pressure, SBP/DBP=systolic/diastolic blood pressure, MAP=mean arterial blood pressure
FiO2=fraction of inspired oxygen, Peep=positive end expiratory pressure, MV=mechanical ventilation
APMHR=age predicted maximum heart rate, RASS=Richmond Agitation Sedation Scale, DOE=dyspnea on exertion

Table 4. Outcomes of ICU Mobilization

Study	Study Design (N= subjects)	Levels of Evidence (Sackett)	Physical Therapy Interventions	Functional Outcomes			Other notable findings
				Strength/ ROM	QOL	Mobility	
Martin UJ. 2005[30]	Retrospective One-group pretest-posttest design N = 49 enrolled; 49 completed study)	4	Treatment group underwent UE/ LE ther ex., trunk control tasks; cycle ergometry, inspiratory muscle training and functional training x 5 days/ week	Increased UE/ LE strength as measured on 5 point scale; increased inspiratory muscle force (maximal NIF)	N/A	All patients bedridden initially; Following rehab program, patients demonstrated higher scores on FIM for supine <> sit and sit<> stand but no differences for ambulation/ stairs	• setting is a post intensive care unit (vent rehab unit; MV > 14 days) • negative correlation between UE strength at admission and weaning duration • no control group
Chiang LL. 2006[22]	Prospective RCT (N = 39 enrolled; 32 completed study) (15 control; 17 treatment group)	2B	Treatment group underwent UE/ LE ther ex., breathing retraining ex., and functional training x 5 days/ week x 6 weeks	Increased UE/ LE strength (hand-held dynamometry) and respiratory muscle force (PI_{max} & PE_{max})	N/A	Treatment group had higher scores on FIM and Barthel Index following 3 and 6 weeks of PT intervention	• setting is a post-ICU ◊ median MV days≥ 46 ◊ may not be applicable to acute care/ ICU • increased vent free time in treatment group • moderate correlation b/w limb strength and ADL performance and mobility • impaired cognitive status at a baseline improved throughout intervention period • small sample size
Bailey P. 2007[23]	Prospective One-group pretest-posttest design (N=103 patients)	4	Twice daily PT/ activity session	N/A	N/A	Median distance ambulated by survivors was 64.6 meters	• Study provides criteria (neurologic/ circulatory/ respiratory) for initiating mobility • Study verifies that early mobilization of ICU patients can be achieved • Increased number of co morbid conditions did not influence ambulatory status • Ambulation distance at ICU discharge may predict post-acute d.c. destination • No control group for comparison
Morris PE. 2008[25]	Prospective Cohort study (N=330; 165 intervention; 165 "usual" care")	2B	Mobilization program implemented 7 days/ week by "mobility team" consisting of PT, critical care RN and nursing assistant	N/A	N/A	Intervention group reached mobilization milestones sooner (eg: day to first OOB)	• Protocol for mobilization is well defined • Intervention group had shorter hospital & ICU lengths of stay potentially leading to cost savings • Intervention group had increased PT frequency throughout hospital length of stay • On average, protocol patients initiated OOB 7 days earlier compared to usual care • No differences in MV duration or d.c. destinations • Nonrandomized
Thomsen GE. 2008[24]	Prospective One-group pretest-posttest design [N = 104 patients (91 Survivors)]	4	Functional mobility training (ROM; sitting at edge of bed and OOB; ambulation)	N/A	N/A	More advanced mobilization activities (OOB transfers & sitting; ambulation) increased within 24 hours of transfer to the unit where mobilization is emphasized	• Mean distance of ambulation at d.c. was ≥ 200 feet • Sedatives, even intermittent sedation administration decreased likelihood of ambulation • female gender and reduced illness severity (ie, APACHE score) associated with greater ambulation
Schweickert WD. 2009[20]	Prospective RCT (N=104; all patients completed study)	1B	Treatment group underwent progressive UE/ LE ther ex., trunk control/ balance activities and functional training including ADL's x 7 days/ week	No difference in UE/LE strength as measured by MRC or hand grip	N/A	Increased % of intervention group returned to functional baseline as defined by FIM and Barthel Index and had greater unassisted walking distance at hospital d.c.	• Early mobilization associated with reduced incidence of delirium and ventilator free days • MV did not preclude acquisition of mobility milestones • Study included performance of ADL's • 87% of therapy sessions completed • No differences in ICU or hospital length of stay • No differencein ICU-acquired weakness
Burtin C. 2009[21]	Prospective RCT (N = 90 enrolled; 67 completed) (36 control; 31 treatment group)	2B	Both groups received UE/ LE ther ex and functional training x 5 days/ week treatment group had additional cycling session x 20 minutes total duration x 5 days/ week	Hand held dynamometry: no difference in quadriceps muscle force at ICU d.c. but increased quadriceps muscle force noted at hospital d.c.; No difference in hand grip strength at either time point	Improved QOL (SF-36 PF) at time of hospital d.c.	No differences at time of discharge from ICU. Treatment group had increased 6 MWT distance and at time of hospital discharge	• moderate correlation between quadriceps strength and 6 MWT and SF-36 • trends noted for proportion of patients who were ambulatory and/ or discharged home (study not adequately powered) • no differences in ability to transfer from sit<> stand or ambulate independently between groups • no differences in weaning time, length of ICU or hospital stay

Needham DM 2010[26]	Prospective QI project Case controlled (N = 57 total (27 pre QI; N=30 post QI)	3B	Functional mobility training (supine to sit; sitting at edge of bed; OOB transfers; ambulation)	N/A	N/A	Greater percentage of patients engaged in more advanced mobilization (i.e.: OOB activities)	Additional QOL goals accomplished: • increase number of PT/ OT consults & interventions; reduction in missed PT/ OT sessions • reduced use of sedative drugs • increased alertness with reduced delirium • reduced ICU and hospital LOS
Morris PE 2011[18]	Retrospective cohort analysis of survivors from prior study*** (see Morris 2008) N = 258 of 280 survivors of acute respiratory failure	2B	Mobilization program implemented 7 days/ week by “mobility team” consisting of PT, critical care RN and nursing assistant	N/A	N/A	Patient participation in an ICU mobilization program was associated with reduced hospital readmission or death in the year following hospitalization	• Study determined additional variables associated with hospital readmission including female gender, co-morbidties, and tracheostomy • >50% of survivors will have a readmission or die in the year following hospitalization
Montagnani G 2011[31]	Retrospective Non-equivalent Pretest-Posttest Control Group Design (N= 56 weaning program (WP); N= 63 pulmonary rehab (PR))	4	WP patients performed UE/ LE ther. ex including UE/ LE cycling and mobilization 6 days/week PR subjects exercise on treadmill/ UE/ LE ergometer and low intensity PRE’s daily x 15- 21 days	N/A	Dyspnea scores declined in both groups	Both groups demonstrated improvement in FIM scores	• Setting was post-acute/ long-term weaning center • Included objective measurement of dyspnea • FIM may be useful outcome tool in this novel setting for patients who require prolonged MV ◊ Patients who are deemed “difficult to wean” • Not randomized with small sample size
PT=physical therapy, OT=occupational therapy, MV=mechanical ventilation, NIF=negative inspiratory force, QOL=quality of life, N/A=not applicable FIM=functional independence measure, PImax=peak inspiratory pressure, PEmax=peak expiratory pressure, HR= heart rate, ICU=intensive care unit D.C.=discharge, c/o=complains of, s/p=status post, OOB=out of bed, RN=nurse, RCT=randomized controlled trial, LOS=length of stay APACHE=acute physiology and health evaluation score, 6MWT=six minute walk test, MRC=Medical research council SF-36=short form health survey							

Table 5. Medical Research Council (MRC) Scoring System for Muscle Strength*

Score	Description		
0	No visible contraction	Movements Assessed	
1	Visible muscle contraction, but no limb movement	**Upper Extremity:**	**Lower Extremity:**
2	Active movement, but not against gravity	Shoulder abduction	Hip flexion
3	Active movement against gravity	Elbow flexion	Knee Extension
4	Active movement against gravity and resistance	Wrist extension	Dorsiflexion
5	Active movement against full resistance		
Maximum score: 60 (4 limbs; 3 movements per extremity with maximum score of 15 points per limb) Minimum score: 0 (quadriplegia)			
*Adapted from Schweickert and Hall. ICU-Acquired Weakness. *Chest*. 2007;31:1541-1549.			

tion lasting less than 3 minutes. In studies that reported on adverse events, accidental removal of patient support equipment happened rarely (<1%) further highlighting the safety of patient mobilization. Burtin et al[21] reported one Achilles tendon rupture in their intervention group that used in-bed cycle ergometry. There were no serious adverse events that required life saving measures or alterations in the patient’s medical care.

FUNCTIONAL OUTCOMES

Muscle Strength

Extremity muscle strength was measured by hand-held dynamometry or manual muscle testing [eg, Medical Research Council (MRC) scoring] in 4 studies as noted in Table 4 and defined in Table 5. Medical Research Council scores, handgrip, and extremity strength did not differ at time of discharge from the ICU[20,21] but Burtin et al[21] showed increased quadriceps muscle force at time of hospital discharge. In postacute settings where patients were mechanically ventilated for a minimum of 14 days prior to transfer, strength gains were observed. In one study,[30] subjects were mechanically ventilated for a median duration of 46 to 52 days (22.8 ± 80.8 days) and demonstrated upper extremity/ lower extremity (UE/ LE) strength gains measured by dynamometry. In another study[30] patients were mechanically ventilated for 18.1 ± 7 days and also demonstrated UE/LE strength gains by manual muscle testing (MMT). Both studies found increases in respiratory muscle strength.

Functional Mobility: The most frequently described functional outcomes assessed were: time to mobility milestones [eg, time to first out of bed (OOB), standing]; ambulation distance,[24] the Barthel Index,[33] the Functional Independence Measure (FIM)[34] or select parts of the FIM [Functional Status Score in the ICU (FSS-ICU)].[4] The FSS-ICU, similar to the FIM, rates functional activities between 1 (total assist) and 7 (complete independence). A score of 0 is assigned if a patient is unable to perform a task. Only 5 of the items from the FIM are included: (1) rolling, (2) transfer from supine to sit, (3) sitting at the edge of bed, (4) transfer from sit to stand, and (5) ambulation are combined in the cumulative FSS-ICU score.[4]

Mobility milestones were accomplished earlier in the intervention groups than the comparison groups in 4 studies.[20,24-26] Compared to controls, ambulation frequency was greater in the study by Thomsen et al[24] and ambulation distance was greater at time of hospital discharge in the studies by Schweickert et al[20] and Burtin et al.[21]

Objective measures such as the FIM & Barthel Index improved in the intervention groups at time of hospital discharge but without significant differences at time of ICU discharge in the study by Schweickert et al.[20] In the postacute care setting, bed mobility and transfers were improved in 3 studies[22,30,31] but ambulation/locomotion were only improved in the studies by Chiang et al[22] and Montagnani et al.[31]

Quality of Life & Patient Symptoms: Burtin et al[21] noted improvements in the physical functioning (PF) subscore of the SF-36 at time of hospital discharge but quality of life (QOL) was not reported for the transition from ICU to ward. Dyspnea was measured in the postacute care setting in the study by Montagnani et al.[31] These patients were hospitalized for approximately 40 days prior to postacute admission, had tracheostomies, and required prolonged mechanical ventilation. The symptom of dyspnea was reduced following the rehabilitation period.

DISCUSSION

The focus of critical care medicine in the ICU is restoration of physiological or hemodynamic stability and prevention of death. The historical approach to achieve these goals has included long periods of immobility and bedrest. The impact of life-sustaining ICU technology on patients that have required sedation, long-term mechanical ventilation, and bedrest has been profound with respect to severe muscle weakness, functional impairments, and loss of quality of life.[15] By understanding the negative sequella of ICU-induced bed rest, investigators are attempting to correct these derangements by reducing the dosage and frequency of sedative medication and mobilizing critically ill patients once hemodynamic stability has been achieved. We have reviewed published reports that have studied this clinical approach.

Safety: Studies included in this review persuasively conclude that the mobilization of critically ill but stable patients in the ICU and immediate postacute environment, who have required a period of mechanical ventilation, can be done safely with minimal risk to the patient. Although most studies included patients receiving 4 or more days of mechanical ventilation, Pohlman et al[20] demonstrated the safety of physical therapy intervention occurring within two days of intubation. The most common untoward event was transient oxygen desaturation that was attenuated by rest and increasing the FiO_2 delivered to the patient. Line dislodgment and/or accidental extubation, frequently mentioned dangers of mobilization, happened rarely, further highlighting the safety profile of patient mobilization.

In all studies, hemodynamic, respiratory, and cognitive criteria were established *a priori* to ensure patient safety (Table 3). These criteria guided the clinicians to determine patient eligibility for mobilization and, it is presumed, limited untoward events by providing the treating physical therapist and/or occupational therapist parameters to guide the intensity of the mobilization sessions. Mobilization was loosely described in most studies citing therapist discretion for advancing activities based on patient tolerance and stability. However, Stiller et al[27] provided an algorithm for initiating and terminating therapy sessions based on physiologic and laboratory data while Morris et al[25] provided an algorithm for mobility progression based on patient's physical capabilities.

Overall activity-induced increases in HR, BP, respiratory rate (RR), tidal volume, and minute ventilation were within acceptable ranges, challenging the perception that patients in the ICU are "too sick" to participate in mobilization activities.[4,27,28] As noted multiple studies have reported on safety and feasibility but the lack of reported negative events could reflect a bias of nonreporting of adverse incidents.

Muscle Strength: Although it is generally accepted that patients in critical care settings for prolonged periods of time are often "bed ridden," deconditioned, and weak, muscle strength was infrequently reported as an outcome measure in the reviewed studies. In studies that did address muscle force production, strength was not significantly improved in the ICU[20,21] but did improve by the time of discharge from the hospital.[21] Interestingly, strength was consistently improved in the postacute care setting.[22,30]

Functional Mobility: The literature reviewed supports improvements in functional mobility following early and progressive physical therapy/occupational therapy (PT/ OT) in the ICU but the measurement of this outcome was not uniform across the literature. For example, as mentioned in the results section, variability of outcome measurements included acquisition of mobility milestones,[18,20,21,23,24,26] FIM,[20,22,30,31] FSS-ICU,[4] and the Barthel Index.[33] Time to mobility milestones was reduced and patient participation in advanced mobilization activities occurred more frequently in ICUs where mobilization and PT/ OT were emphasized.[20,24-26] Within the ICU setting, objective measures such as the FIM & Barthel Index were used infrequently although two of the cited studies used these tools.[4,20]

The FIM and Barthel Index scores improved in the intervention group in the study by Schweickert et al[20] with over 59% of patients achieving functional independence (FIM ≥ 5) compared to 35% of the control group at time of hospital discharge. The FIM scores also improved following rehabilitation in the postacute setting.[22,30,31] Use of the FIM, or the related FSS-ICU[4] to measure patient disability and to compare functional outcomes is attractive since the tool is well known to rehabilitation professionals. However, the validity and reliability of this tool has not been established in the ICU setting.

Quality of Life & Patient Symptoms: Quality of life and patient symptoms were seldom measured within the ICU. One study[21] measured QOL and one study measured patient's symptoms.[31] Burtin et al[21] demonstrated improvements in the physical functioning domain of the SF-36 at hospital discharge while Montagnani et al[31] reported reduced patient dyspnea. As noted in the introduction, quality of life and neuropsychological impairments such as depression, anxiety, and posttraumatic stress disorder are negatively impacted by prolonged mechanical ventilation and ICU duration. Rehabilitation in the ICU and its influence on these factors should be an area of future research.

The physiology and complications of bed rest are well understood. Intensive care unit-acquired weakness and functional dependency are recognized as unfortunate consequences of prolonged duration in ICUs and mechanical ventilation. Although sedative medications are used to reduce metabolic energy demand for patients in respiratory failure they inhibit participation in exercise and functional activity and often cause disturbances in levels of arousal. Despite the inherently complex environment and challenges that face critical care teams, including the human resources required to safely mobilize patients, feasibility and safety has been demonstrated as noted in Table 2. Critically ill patients can exercise, sit up, transfer to bedside chairs, and ambulate in the hallways; however, few published papers have randomized and controlled this intervention. The work of Schweickert et al,[20] Burtin et al,[21] and Chiang et al[22] have found that participation in monitored programs of physical activity can lead to statistically significant improvements in ambulation independence, reduced duration of mechanical ventilation, better ability to perform self care activities, and improved respiratory function.

CONCLUSION/IMPLICATIONS FOR FUTURE RESEARCH

In summary, the body of evidence that has studied the mobilization of critically ill patients is small. The few randomized controlled trials include a total of only 171 patients limiting the strength of evidence. Based on the studies reviewed, early physical therapy and ICU mobilization is feasible and safe. Acquisition of mobility milestones is enhanced in ICUs that promote early rehabilitation. Improvements in quality of life and muscle strength cannot be determined at this time.

In reviewing the literature, there are several questions that must be addressed. These questions include, but are not limited to: (1) How do published papers reflect current practice as mobilization has been reported in a small percentage of ICUs? (2) What is the appropriate level of clinical expertise or experience required to safely work in a critical care environment? (3) What intensity, frequency, and dose of physical activity will lead to optimal patient outcomes? (4) What generalization to other patient populations can be made since the majority of patients studied are found in medical ICUs? (5) Should all patients who require mechanical ventilation or ICU admission be referred to physical therapy? And (6) Are there optimal patient populations who would benefit most from early mobilization, as well as populations for whom physical therapy is clearly contraindicated? The answer to these questions will provide an evidence-based approach to optimize patient outcomes for the critically ill patient.

REFERENCES

1. Morris P. Moving our critically ill patients: mobility barriers and benefits. *Crit Care Clin.* 2007;23:1-20.
2. Truong AD, Fan E, Brower RG, Needham DM. Mobilizing patients in the intensive care unit-from pathophysiology to clinical trials. *Crit Care.* 2009;13:216.
3. Kress JP, Clinical trials of early mobilization of critically ill patients. *Crit Care Med.* 2009;37[Suppl.]:s442-s447.
4. Zanni JM, Korupolu R, Fan E, et al: Rehabilitation therapy and outcomes in acute respiratory failure: an observational pilot project. *J Crit Care.* 2010;25(2):254-262.
5. Hodgin KE, Nordon-Craft A, McFann KK, Mealer ML, Moss M. Physical therapy utilization in intensive care units: Results from a national survey. *Crit Care Med.* 2009;37(2):561-566; quiz 566-568.
6. Norrenberg M, Vincent JL. A profile of European intensive care unit physiotherapists. *Intensive Care Med.* 2000;26:988-994.
7. Nava S, Ambrosino N. Rehabilitation in the ICU: the European phoenix. *Intensive Care Med.* 2000;26:841-844.
8. Dejonghe B, Sharshar T, Lefaucheur JP, et al. Paresis acquired in the intensive care unit: A prospective multicenter study. *JAMA.* 2002;288:2859-2867.
9. Stevens RD, Dowdy DW, Michaels RK, et al. Neuromuscular dysfunction acquired in critical illness: a systematic review. *Intensive Care Med.* 2007;33(11):1876-1891.
10. Herridge MS, Cheung AM, Tansey CM, et al. One year outcomes in survivors of the acute respiratory distress syndrome. *N Engl J Med.* 2003;348:683-693.
11. Cheung AM, Tansey CM, Tomlinson G, et al. Two-year outcomes, health care use and costs in survivors of ARDS. *Am J Resp J Crit Care Med.* 2006;174:538-544.
12. Herridge MS, Tansey CM, Matte A, et al. Functional disability 5 years after acute respiratory distress syndrome. *N Engl J Med.* 2011;364:1293-1304.
13. Harper CM, Lyles YM. The physiology and complications of bedrest. *J Am Geriatr Soc.* 1988;36(11):1047-1054.
14. Bergouignan A, Rudwill F, Simon C, Blanc S. Physical inactivity as the culprit of metabolic inflexibility: evidences from bedrest studies. *J Appl Physiol.* 2011 Aug 11 (Epub ahead of print).
15. Bloomfield SA. Changes in musculoskeletal structure and function with prolonged bedrest. *Med Sci Sports Exerc.* 1997;29(2):197-206.

16. Brower RG, Consequences of bed rest. *Crit Care Med.* 2009;37(10):422-428.
17. Hopkins RO, Spuhler VJ, Thomsen GE. Transforming ICU culture to facilitate early mobility. *Crit Care Clin.* 2007;23:81-96.
18. Morris PE, Griffen L, Berry M, et al. Receiving early mobility during and intensive care unit admission is a predictor of improved outcomes in acute respiratory failure *Am J Med Sci.* 2011;341(5):373-377.
19. Centre for Evidence-based Medicine. Levels of Evidence (March 2009) Website. Available at www.cebm.net. Accessed September 26, 2011.
20. Schweickert WD, Pohlman MC, Pohlman AS. Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomized controlled. *Lancet.* 2009;373:1874-1882.
21. Burtin C, Clerckx B, Robbeets C, et al. Early exercise in critically patients enhances short-term functional recovery. *Crit Care Med.* 2009;37(9):2499-2505.
22. Chiang LL, Wang LY, Wu CP, Wu HD, Wu YT. Effects of physical training on functional status in patients with prolonged mechanical ventilation. *Phys Ther.* 2006;86:1271-1281.
23. Bailey P, Thomsen GE, Spuhler VJ, et al. Early activity is feasible and safe in respiratory failure patients. *Crit Care Med.* 2007;35(1):139-145.
24. Thomsen GE, Snow GL, Rodriguez L, Hopkins RO. Patients with respiratory failure increase ambulation after transfer to an intensive care unit where early activity is a priority. *Crit Care Med.* 2008;36(4):1119-1124.
25. Morris PE, Goad A, Thompson C, et al. Early intensive care unit mobility therapy in the treatment of acute respiratory failure. *Crit Care Med.* 2008;36(8):2238-2243.
26. Needham DM, Korupolu R, Zanni JM, et al: Early physical medicine and rehabilitation for patients with acute respiratory failure: a quality improvement project. *Arch Phys Med Rehabil.* 2010;91:536-542.
27. Stiller K, Phillips, AC, Lambert P. The safety of mobilisation and its effects on haemodynamic and respiratory status of intensive care patients. *Physio Theory Pract.* 2004;20:175-185.
28. Bourdin G, Barbier J, Burle JF, et al. The feasibility of early physical activity in intensive care unit patients: A prospective observational one-center study. *Resp Care.* 2010;55:400-407.
29. Zafiropoulus B, Allison JA, McCarren B. Physiological responses to the early mobilization of the intubated, ventilated abdominal surgical patient. *Austr J Physiother.* 2004;50(2):95-100.
30. Martin UJ, Hincapie L, Nimchuk M, Gaughan J. Criner GJ. Impact of whole-body rehabilitation in patients receiving chronic mechanical ventilation. *Crit Care Med.* 2005;33(10):2259-2265.
31. Montagnani G, Vagheggini G, Panait Vlad E, Berrighi D, Pantani L, Ambrosino N. Use of the functional independence measure in people for whom mechanical ventilation is difficult. *Phys Ther.* 2011;91(7):1109-1115.
32. Pohlman, MC, Schweickert WD, Pohlman AS et al. Feasibility of physical and occupational therapy beginning from initiation of mechanical ventilation. *Crit Care Med.* 2010;38:2089-2094.
33. MahoneyFI, Barthel DW. Functional evaluation: the Barthel Index. *Md State Med J.* 1965;14:61-65.
34. Keith RA, Granger CV, Hamilton BB, Sherwin FS. The functional independence measure: a new tool for rehabilitation. *Adv Clin Rehabil.* 1987;1:6-18.