Clinical Practice Guideline: Early Mobilization and Rehabilitation of Critically Ill Burn Patients

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This Clinical Practice Guideline addresses early mobilization and rehabilitation (EMR) of critically ill adult burn patients in an intensive care unit (ICU) setting. We defined EMR as any systematic or protocolized intervention that could include muscle activation, active exercises in bed, active resistance exercises, active side-to-side turning, or mobilization to sitting at the bedside, standing, or walking, including mobilization using assistance with hoists or tilt tables, which was initiated within at least 14 days of injury, while the patient was still in an ICU setting. After developing relevant PICO (Population, Intervention, Comparator, Outcomes) questions, a comprehensive literature search was conducted with the help of a professional medical librarian. Available literature was reviewed and systematically evaluated. Recommendations were formulated through the consensus of a multidisciplinary committee, which included burn nurses, physicians, and rehabilitation therapists, based on the available scientific evidence. No recommendation could be formed on the use of EMR to reduce the duration of mechanical ventilation in the burn ICU, but we conditionally recommend the use of EMR to reduce ICU-acquired weakness in critically ill burn patients. No recommendation could be made regarding EMR's effects on the development of hospital-acquired pressure injuries or disruption or damage to the skin grafts and skin substitutes. We conditionally recommend the use of EMR to reduce delirium in critically ill burn patients in the ICU.

American Burn Association Clinical Practice Guideline Ad hoc Committee

In October 2020, the Board of Trustees of the American Burn Association (ABA) created an ad hoc committee to develop and maintain current clinical practice guidelines for burn care. The committee members were selected from the ABA's membership and include providers from many burn care subspecialties. This committee includes all the listed authors for this clinical practice guideline.

Purpose

The purpose of this Clinical Practice Guideline (CPG) is to make recommendations, based on the available scientific literature, on the use of early rehabilitation and mobilization interventions in critically ill burn patients. In this CPG, the term "early" refers to the first 14 days postburn injury, while the patient is critically ill and in an intensive care unit (ICU) setting. While positioning, passive stretching, and splinting are fundamental standards of early burn rehabilitation care, these were not the interventions of interest in this CPG. Rather, we were interested in the use of any systematic or protocolized interventions that could include muscle activation, active exercises in bed, active resistance exercises, active side-to-side turning, or mobilization to sitting at the bedside, standing, or walking, including mobilization using assistance with hoists or tilt tables.

We recognized that while early mobilization and rehabilitation (EMR) has been extensively studied in the non-burn ICU population,[1] the literature on this topic involving critically ill burn patients would be limited. We recognized the importance of carefully considering whether EMR practices in non-burn ICU patients could be translated to the specialized burn population which has unique analgesia, sedation, and surgical needs during the acute critical illness phase of treatment. We also wished to review any specific safety concerns related to EMR of critically ill burn patients.

Users

This CPG will be of most use to nurses, physicians, and rehabilitation therapists who provide care to critically ill patients in the burn-ICU. The teamwork between burn nurses and rehabilitation therapists is highly important; mobilization

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interventions must be fit into the busy hour-to-hour ICU care plan, and nurses frequently are asked to assist the therapists with mobilization. Mobilization should also be one of the items on the checklist during daily burn team rounds in the burn ICU. As such, this CPG will be of interest to members of the burn team who participate in these daily rounds.

Clinical Problem and Scientific Background

Critically ill patients in the ICU are subjected to prolonged bedrest and immobilization. This results from the severe nature of critical illness itself, sedation and analgesia medications, and the use of invasive monitors and devices. Consequently, the cardiovascular system becomes deconditioned, skeletal muscles atrophy, and the respiratory muscles and diaphragm progressively weaken during controlled mechanical ventilation (MV). Additionally, the bedridden critically ill patient experiences anxiety, isolation, and an inability to communicate. As a result, ICU survivors may face a variety of both short- and long-term morbidity from bedrest and immobilization. The duration of MV may be lengthened. Delirium may develop while the patient is still in the ICU. Profound generalized muscle weakness (termed ICU-acquired weakness [ICUAW])[2] can develop rapidly and may persist well after hospital discharge. Even as late as 5 years after ICU discharge, many survivors have not regained normal physical function and suffer from ongoing physical problems, psychological complaints, and the overall diminished physical and mental quality of life.[3] In fact, post-intensive care syndrome (PICS) has been recognized as a distinct constellation of poor physical, functional, and cognitive outcomes lasting years after the patient left the ICU.[4, 5]

Among non-burn ICU patients, there has been concentrated interest in the use of systematic early mobilization to prevent or lessen the adverse effects of prolonged bedrest and immobilization. It is thought that active mobilization interrupts the pathophysiology of ICUAW, for example, which is thought to involve muscle injury from systemic inflammation, and muscle atrophy and deconditioning from disuse.[6, 7] Exercise and muscle activation maintain muscle strength and appear to help reduce inflammation.[8]

Several systematic reviews and meta-analyses of randomized controlled trials (RCTs) of systematic early mobilization in ICU patients have been conducted.[1, 9–14] While some of these systematic reviews concluded that early mobilization lessened ICU-acquired muscle weakness or improved some measures of physical function,[9, 11, 12, 14] shortened the duration of MV,[14] and improved health-related quality of life following hospital discharge,[14] others were either inconclusive or found no consistent effect of early mobilization on these outcomes,[1, 10, 12, 13] including the development of delirium or other mental health sequelae.[11] There are several reasons for these varying findings. First, the timing of the mobilization intervention appears to be important[1] and differs between studies. Second, the early mobilization intervention (eg, method, dose, and intensity), the comparator (eg, no mobilization, "standard" mobilization, and non-protocolized rehabilitation), and the timing of the outcome measurement vary considerably between studies. Finally, the study populations are heterogeneous. Furthermore, some systematic reviews and meta-analyses identified a high risk of bias among many of the included RCTs[1, 10, 12] and had low overall confidence in the literature.[10]

Nonetheless, many professional societies and organizations have published clinical practice guidelines that recommend early mobilization of ICU patients.[15–19] Finally, while early mobilization of patients in the ICU is generally considered to be safe and feasible,[20] one systematic review had low certainty in the scientific evidence on the risk of adverse events.[10]

We would anticipate that the problem of prolonged bedrest and immobilization leading to ICUAW, prolonged ventilatory support, and PICS would be especially problematic among burn patients in the ICU. Many factors act together to cause progressive weakness and deconditioning in critically ill burn patients: The hypermetabolic response after a major burn features catabolic erosion of the skeletal muscles and wasting of the lean body mass which may persist for years after the injury.[21, 22] Bedrest is frequently prolonged because of lengthy critical illness, extensive wounds, pain, and multiple surgeries. Pain, stiffness, bulky dressings, postoperative restrictions on movement after skin grafting, and the often large amounts of analgesics and anxiolytics that are required can all interfere with the patient's ability to mobilize and actively exercise. Critically ill burn patients are also subject to short- and long-term pulmonary dysfunction from smoke inhalation injury, pulmonary inflammation, and repetitive lung infections.[23, 24] Prolonged cardiac stress characterized by tachycardia and increased myocardial oxygen consumption, lasting for years after the burn injury, is another problem encountered among severely burned patients.[25] Finally, numerous staged operations to excise and skin graft burn wounds under general anesthesia raise the risks of postoperative cognitive dysfunction and delirium.[26] Therefore, the critically ill burn patient is exposed to multiple insults which could potentially increase the risk of progressive weakness, deconditioning, and cognitive decline that will ultimately lead to not only acute problems, such as ICUAW and prolonged MV, but also post-discharge functional limitations and diminished health-related quality of life. So far, these problems have not been well studied in burn survivors.

Later exercise rehabilitation programs that focus on skeletal muscle strengthening, and cardiovascular reconditioning, initiated at hospital discharge, have shown benefits among severely burned patients, including improved lean body mass, strength, fitness, and endurance.[27–29] However, relatively little is known about the effects of instituting active exercise training *early* after burn injury while the patient is still in the burn ICU. Many high-volume burn centers institute early mobilization along with resistive and aerobic exercise training for patients in the burn ICU, but the approaches are heterogeneous and no standardized guidelines exist.[30]

METHODS

For the development of this guideline, the CPG Committee met virtually on several occasions and communicated electronically. Through discussion and consensus, the committee identified clinically important questions and definitions pertaining to the topic of "early rehabilitation and mobilization in critically ill burn patients". The questions were designed using a PICO approach (*Patient*: the patient population to

whom the recommendations apply, *Intervention*: the therapeutic or diagnostic intervention of interest, *Comparator*: The alternative approach to the intervention (used in the control group), *Outcome*: The outcome(s) of interest for the clinical problem). The authors developed the following four clinically important questions surrounding the topic of EMR in the burn ICU:

1. Among critically ill burn patients in an intensive care setting, does EMR, compared with nonstandardized or late mobilization and rehabilitation, (a) shorten the duration of MV and (b) reduce the development of ICUAW?
2. Among critically ill burn patients in an intensive care setting, does EMR, compared with nonstandardized or late mobilization and rehabilitation, result in fewer pressure injuries?
3. Among critically ill burn patients in an intensive care setting, does EMR, compared with nonstandardized or late mobilization and rehabilitation, result in loss of skin grafts or skin substitutes?
4. Among critically ill burn patients in an intensive care setting, does EMR, compared with nonstandardized or late mobilization and rehabilitation, reduce the prevalence of delirium?

Search Strategy

A comprehensive literature search based on these four PICO questions was conducted by a professional medical librarian (H.T.L.). The three main concepts and the Boolean Logic involved in the search included: (Burn/Burn Patients) AND (critically ill/ICU/mechanical ventilation) AND (early mobilization or early rehabilitation or early occupational therapy or early physical therapy). All outcomes identified in the four clinically relevant PICO questions were considered. The search involved the following databases: Ovid MEDLINE, Embase, the Cumulative Index of Nursing and Allied Health Literature (CINAHL), and the Cochrane Central Register of Controlled Trials (Central). For MEDLINE, we used the complete file that included published articles, Epub Ahead of Print, In-Process, In-Data-Review & Other Non-Indexed Citations. We restricted results to English only and searched from the inception of the database to April 29, 2021.

The search yielded a total of 286 articles and three clinical trials registered on ClinicalTrials.gov that are currently in process (Figure 1). Rayyan™ reference management software (Rayyan Systems Inc., Cambridge, MA, USA) was used to upload and organize the articles. Following the removal of 56 duplicate articles, two committee members (R.C. and B.N) independently evaluated the titles and abstracts of the remaining 230 citations to identify articles suitable for full-text review. Further duplicates, articles published only as abstracts, surveys, case reports, and unrelated articles were excluded. Consensus between the two reviewers (R.C. and B.N.) was reached on May 14, 2021, to include 15 articles for an initial full-text review.

Articles selected for initial full-text review were then independently screened for inclusion by three committee members (R.C., J.R., and L.J.) to determine if they addressed any of the PICO questions, based on the following mandatory set of inclusion criteria: 1) The study had to involve burn patients in an ICU setting, 2) There had to be a defined EMR intervention, 3) There had to be a comparator (eg, no early rehabilitation/mobilization, "standard" or "traditional" rehabilitation/mobilization, or late rehabilitation/mobilization), and 4) At least one of the predefined PICO outcomes had to have been measured and reported. Following an independent review, the three reviewers (R.C., L.J., and J.R.) met virtually and reached a consensus on June 10, 2020, on which articles to finally include.

Three articles[31–33] met these criteria and have been included in this clinical practice guideline (Table 1). Two articles[34, 35] were dropped because although a clear early rehabilitation intervention, comparator, and outcome were described, their study populations contained burn and trauma patients with less than 9%[34] and less than 7.5%[35] of the study populations being burn patients, with no subgroup analyses of the burn patients alone. The remaining 10 articles were dropped as they did not meet the criteria to address any of our PICO questions.

The three included articles[31–33] were systematically and independently evaluated by three committee members (R.C., D.L., and B.N.) using the critical appraisal form described by Law et al.[36] These members then met virtually on July 5, 2021, to compare each other's results and scores. Differences in the total score were resolved by consensus. The consensus scores for the quality of evidence in each of these studies are presented in Table 2. Subcommittees were then formed to address each PICO question and write a review using the selected articles, and where there was insufficient burn literature, RCTs and/or systematic reviews and meta-analyses from the non-burn ICU literature were reviewed. The committee met virtually on December 8, 2021, to form recommendations by consensus, based on the available scientific evidence.

> *Question 1: Among critically ill burn patients in an intensive care setting, does EMR, compared with nonstandardized or late mobilization and rehabilitation, (a) shorten the duration of MV and (b) reduce the development of ICUAW?*

For this question, we defined EMR as any physical or occupational therapy that involves muscle activation or mobilization from recumbent or semi-recumbent position to sitting, standing, or walking within 7 days of burn injury even if receiving MV. This would be performed according to a clearly defined protocol or criteria. "Early mobilization and rehabilitation" for this question does not include passive mobilization and stretching to prevent joint contractures. The comparator for this question could include no mobilization, any undefined or nonstandardized mobilization program or "standard" mobilization, or mobilizing after 7 days. We identified two main outcomes for this intervention: 1) The duration of invasive MV in days and 2) Development of ICUAW documented through objective evaluation, including but not limited to measures such as the Medical Research Council Sum Score (MRC-SS), Physical Function in the ICU Test (PFIT, Barthel Index [BI], Timed up-and-go, 6-minute walk test, SF36-physical function(SF-36PF), or time to walk independently. We selected 7 days as opposed to 14 days as the cutoff to initiate EMR because we believe that commencement of EMR after 7 days, while still relatively "early,"

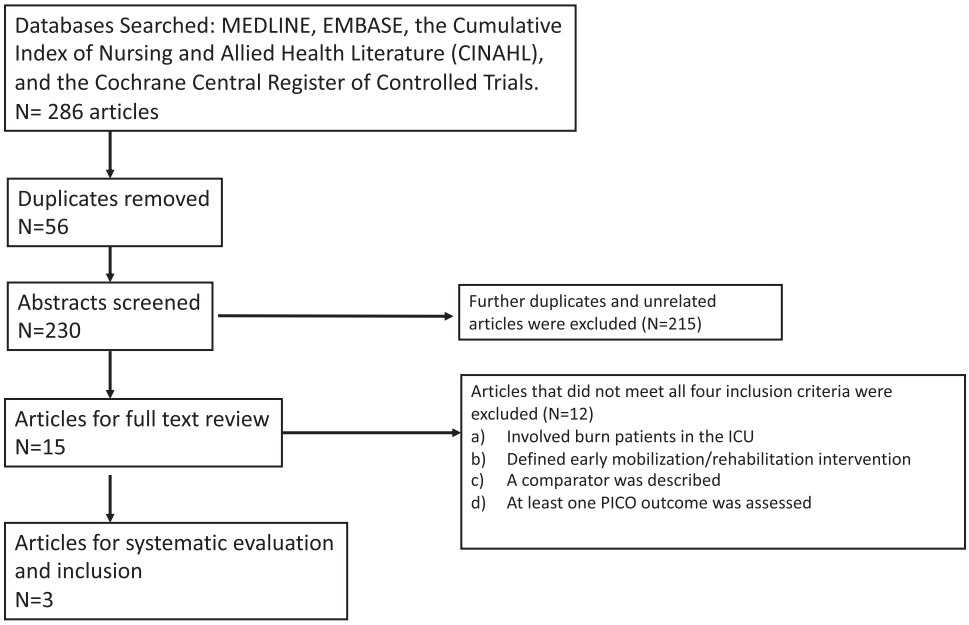

Figure 1. Flow diagram describing search and extraction process for included articles.

would not be early enough to affect the selected outcome measures.

We identified only three low to very low quality[37] interventional studies that evaluated the effects of EMR in critically ill burn patients[31–33] on our outcomes of interest for this question (Tables 1 and 2). The study by Baytieh and Li[32] retrospectively compared burn-ICU patients mobilized early, before the start of any surgical interventions to patients mobilized later, and after the start of surgery. The group mobilized early had a significantly shorter time from the burn to the day of unassisted walking ("independent mobilization") compared with the patients mobilized later (19.5 vs 42.1 days). While this difference in outcome suggests a positive benefit to early mobilization and possibly less ICUAW, there were several limitations that lower our confidence in this finding. Patients mobilized earlier had significantly smaller total burn size than those mobilized later. The extent of lower extremity burns was not described which is important since that center's approach was to not mobilize until 5 days post grafting of legs. Similarly, the number of patients on ventilators in each group was not disclosed. These variables may have affected the time to walk. Details of the intervention ("assisted walking") were missing and included no description of the administering personnel, or the duration, distance, or frequency of walking. Finally, in the early mobilization group, the length of ICU stay was only 4.1 days. Thus, patients may have been able to walk sooner simply by virtue of being out of the ICU and not encumbered by monitors, invasive devices, or affected by the greater anxiolysis and analgesia that is provided to patients in an ICU compared with a ward. The outcome of independent mobilization was not quantified beyond the day it started. There was no description of the "dose" (distance, speed or duration, or frequency per day). This study also looked at a variety of nutritional factors. One interesting finding was that there was a significant correlation between diarrhea and the time to independently ambulate, suggesting that diarrhea is potentially a barrier to mobilizing burn-ICU patients, especially those where a fecal diversion device is in use to manage diarrhea.

Deng et al[31] retrospectively assessed the effects of enhanced early mobilization among adult patients with burns ≥50% TBSA admitted to a burn ICU within 7 days of injury and who survived. The "mobilization training" regimen included a staged program starting with active range of motion (ROM) progressing to transfer to sitting training, then tilt table training, then standing, and ultimately assisted in progressing to independent ambulation. This was compared with a historical "passive training" cohort who only received anti-contracture positioning and passive ROM exercises. The enhanced mobility training did not result in any difference in the days of MV, or the Functional Independence Measure (FIM) and BI measured within one week of burn ICU discharge compared with passive training. However, patients in the mobility training group spent significantly fewer days confined to strict bed rest, fewer days in the burn ICU, and fewer days in hospital compared with the patients who received only passive training. While there was a statistically insignificant trend toward a shorter duration of MV in the mobility training group, we do not know if ventilator weaning protocols were equally applied to either group or the number of patients with tracheostomies in each group; both variables could affect the duration of MV. While the shorter duration of ICU and hospital length of stay (LOS) suggest less impairment of overall function, these are at best surrogate measures of the overall functional capability, strength, and cognitive function. Furthermore, while the groups appeared reasonably well-matched at baseline, the number of deaths, number of patients requiring MV, and measures of organ dysfunction at admission were not disclosed for each group, possibly masking differences in illness severity which might have affected ICU and hospital LOS. Also, the measurement of the FIM and BI just prior to ICU discharge may not reflect later functional status post hospital discharge, and the FIM and BI were not measured in all subjects. Thus, we cannot confidently make any conclusions as to the effects (if any) of early mobilization on the duration of mechanical rehabilitation or ICUAW and later the overall physical functioning, from this study.

Table 1. Descriptions of included studies

Authors	Design	Total Size	Sample	PICO-Relevant Outcome Measure	Intervention	Results
Baytieh et al[32]	Case–control	35	Adults • *Early mobilization* (N = 18, age 42.8 +/– 19 yrs., % TBSA burn 24.8 +/– 11.5). • *Late mobilization* (N = 17, age 40.2 +/– 14.7 yrs, % TBSA burn 39.5 +/– 20.8. [*P* = .028 vs early]).	• Days to independent mobilization ("walking without assistance"). • Other outcomes: diarrhea episodes, ICU LOS, antibiotic administration, time to enteral feeding, first surgery, serum albumin, white cell count.	• *Early mobilization* (intervention) was assisted walking prior to the start of burn surgery (mobilized at 2.3 +/– 1 days postburn). • *Late mobilization* (comparator) was assisted walking after the start of burn surgery (mobilized at 13 +/– 8.3 days postburn).	• Days from burn to independent mobilization were less in the early mobilization group (19.5 +/– 18.4) than in the late mobilization group (42.1 +/– 36, *P* = .033). • The ICU length of stay was shorter in the early mobilization group than in the late mobilization group (4.1 +/– 3.9 days vs 10.8 +/– 7.3 days; *P* = .002). • Significant correlations were identified between longer time to independent mobilization and diarrhea and between shorter time to independent mobilization and higher serum albumin.
Deng et al[31]	Case–control	73	Adults • *Mobility training cohort* (early mobilization group) *N* = 24, age 38.9 +/– 9.4 yrs., % TBSA burn 65.3 +/– 10.1, 58% with INHI. • *Passive training cohort* (control) N = 49, age 40.8 +/– 10.8 yrs, % TBSA burn 70.9 +/– 12.4, 47% with INHI.	• Barthel Index (BI) • Functional independence measure (FIM) (both assessed by blinded rehab therapist 7 days prior to BICU discharge). • Ventilator-dependent days. • Other outcomes: PROM, LOS (BICU, hospital), days of strict bed rest, days of rehab.	• *Mobility training* (intervention) included daily active ROM, progressive HOB elevation, transfer to sitting training b.i.d., tilt table training b.i.d., standing to progressive ambulation. • *Passive training* (comparator) included anticontracture positioning and b.i.d. passive ROM.	• Ventilator-dependent days were 2.7 +/– 6.7 for mobility training and 5.5 +/– 7.6 for passive training (difference ns). • Total BI was 51.3 +/– 31.5 (N = 19) for mobility training vs 55.9 +/– 28.8 (N = 17) for passive training (difference ns) • Total FIM was 81.3 +/– 29.5 (N = 19) for mobility training vs 83 +/– 24.8 (N = 14) for passive training (difference ns). • Cognitive FIM was 30.5 +/– 3.9 (N = 19) for mobility training vs 33.5 +/– 3.7 (N = 14) for passive training (*P* < .001). • The mobility training group also experienced significantly shorter BICU LOS and hospital LOS.

Table 1. Continued

Authors	Design	Total Size	Sample	PICO-Relevant Outcome Measure	Intervention	Results
Gille et al[33]	Case–control	80	Adults • *Protocol group* (group A) N = 38, median age 58.5 (45–67.8), median % TBSA burn 31 (18.9–46), 18.4% with INHI. • *Historical control group* (group B) N = 42, median age 56 (46.3–70.8), median % TBSA burn 30 (25–44.8), 35.7% with INHI.	• Continued ventilation hours after admission. • Total ventilator days. • Other outcomes: perioperative ventilation, pneumonia, sepsis, fluid input volume first 24 hr, urine output first 24 hr, fluid balance over 1–3 days, fluid balance 1–7 days, SOFA score.	• *Protocol for early spontaneous breathing* included 1) extubation < 6 h post admission when possible, 2) avoiding "routine intubation," 3) early postoperative extubation, 4) "intensive" chest physiotherapy including expectorants, and 5) early active mobilization (mobilized to chair or walking if possible). • *Historical control* (comparator) protocol not described.	• *Median continued ventilation hours* after admission was 4.8 (4–22.5) hr in the protocol group vs 378 (8.5–681.5) hr in the controls (P = .0003). • *Median total ventilator days* was 3 (1–5.8) days in the protocol group vs 18.5 (0.5–30.5) in the controls (P = .001).

BICU, Burn ICU; *b.i.d*, twice a day; *HOB*, head of bed;*ICU*, intensive care unit; *INHI*, Inhalation Injury; *LOS*, length of stay; *PICO*, Population, Intervention, Comparator, Outcomes; *PROM*, passive range of motion; *ROM*, range of motion; *SOFA*, sequential organ failure assessment.

Table 2. Evidentiary table: quality of interventional studies

Authors	Study Purpose	Literature Review	Design	Sample		Outcomes			Intervention			Results					
				Size	Details	Justified	Reliable	Valid	Detailed Description	Contamination	Co-Intervention	Statistical Significance	Analysis Appropriate	Clinical Importance	Dropouts Reported	Conclusions Appropriate	Total Score
Baytieh et al[32]	0	1	CC	35	0	0	0	0	0	1	0	1	0	0	1	1	5
Deng et al[31]	1	1	CC	73	1	1	1	0	1	1	1	1	1	1	1	1	13
Gille et al[33]	1	0	CC	80	1	1	1	1	0	0	0	1	1	1	1	1	8

CC, case controlled study.

The study by Gille et al[33] was mainly aimed at facilitating early spontaneous breathing in adults with burns and an abbreviated burn severity index ≥7 who were admitted to the ICU. However, one element of their intervention included "early active mobilization," which appears to have been mobilization starting on postburn day 1 to a chair or walking. The protocol also included early extubation after burn center admission, avoidance of "routine intubation," early postoperative extubation, and aggressive chest physiotherapy including the use of expectorants. Compared with historical controls, patients in the protocol group experienced significant reductions in the continued hours of ventilation after admission, and the total ventilator days compared with patients in the historical control group. In the protocol group, 73% of patients had been extubated within 24 hours compared with only 36% in the controls. Thus, early aggressive extubation alone may have accounted for the significant reduction in continued hours of ventilation and ventilator days observed in the protocol group rather than any specific effect of "early mobilization". Also, the early mobilization protocol was not described in detail (frequency, duration, distance of walking, or use of assistance), and no data were provided to show how much mobilization was administered. Therefore, it is impossible to determine with any confidence the effects of the early mobilization component of this protocol on the duration of ventilation.

Two studies have evaluated EMR among mixed trauma and burn populations in an ICU setting. Neither study was formally included for critical review because burn patients formed a distinct minority in each study and were not separately evaluated. Clark et al[34] conducted a retrospective case–control study of 2176 patients of which 10% were burns (% TBSA burn and inhalation injury not reported), and 75% were blunt trauma. Patients who received a progressive early mobilization protocol did not have a significant reduction in days of MV compared with a historical cohort of patients prior to the institution of the early mobility protocol (7.8 ± 13.4 days vs 8.9 ± 17.4 days, $P = .08$). The development of ICUAW was not evaluated. Coles et al[35] reported a case–control study of 526 adults admitted to a trauma ICU, where 5% of the study population was categorized as "burn/drowning/asphyxia" (with no description or % TBSA burn or inhalation injury). A protocolized early mobilization program (EMP), compared with a historical cohort not receiving this intervention, had no significant effect on ventilator-free days (OR 0.98, 95% CI: 0.79 to 1.21), and ICUAW was not specifically measured. Although both studies utilized detailed and carefully planned early mobilization interventions, we cannot make conclusions on any effects of early mobilization on the outcome of the duration of MV in burn patients, because of the small and undescribed burn populations included in these two studies.

Given the lack of high-quality studies involving critically ill burn patients on the effects of early rehabilitation and mobilization on our outcomes of interest, we reviewed literature from the general ICU population. With respect to the outcome of time spent on the ventilator, numerous RCTs in non-burn ICU patients have assessed the effect of early rehabilitation and mobilization on the duration of MV and/or ventilator-free days.[38–53] One systematic review and meta-analysis[14] of three of these trials,[38, 41, 52] using pooled data and a fixed-effects model, found a small but significant

effect of early rehabilitation and mobilization on improving (increasing) ventilator-free days. However, it should be noted that the physical therapy interventions differed considerably between these three studies; one used lower extremity electrical muscle stimulation (EMS),[52] one added cycling exercises with a bedside cycling ergometer,[41] and one used a variety of early passive and active ROM exercises, with progressive mobilization to ambulation.[38] Also, the comparators used in the control groups were heterogeneous; one approach was to "not use EMS" but with no other detail provided,[52] one used early "standardized" physiotherapy and mobilization without cycling exercises,[41] and one used "standard care" provided later in the hospital stay.[38] Another systematic review[12] that included many of these studies[38–40, 42, 43, 45, 48, 49, 54] was unable to perform a meta-analysis on the outcome of MV duration because much of the data were significantly skewed. In addition, there was considerable heterogeneity between these studies with respect to the comparisons made (eg, systematic early vs late mobilization, systematic early vs standard early mobilization, or systematic early vs no mobilization).

Individually, the vast majority of RCTs have not demonstrated that an early physical therapy intervention produced any significant reduction in the duration of MV[39, 40, 42, 45, 46, 48, 49, 51, 53, 54] or improvement (increase) in ventilator-free days.[41, 42, 45, 48–50]

However, a small number of RCTs have shown an effect of early rehabilitation and mobilization on time spent on a ventilator. Schweickert et al[38] randomly assigned 104 ICU patients either to receive an early exercise and mobilization rehabilitation program or to receive "standard" occupational and physical therapy that started on average almost 6 days later than the intervention. The median duration of MV in all patients was significantly shorter with the intervention (6.1 [IQR 4–9.6] vs 3.4 [2.3–7.3] days; $P = .02$), but the reduction in ventilator time became statistically insignificant when only survivors were evaluated. Median ventilator-free days in the first 28 days were improved (increased) from 21.1 (0–23.8) days in the control group to 23.5 (7.4–25.6) days with the intervention ($P = .05$). Two studies from the same medical center in China,[43, 44] one involving 60 general ICU patients and the other involving 106 post coronary artery bypass grafting (CABG) patients, compared randomly assigned early physiotherapy and mobilization with routine therapy started later. In both studies, patients receiving the intervention experienced significant reductions in duration of ventilation compared with the controls (5.6 ± 2.1 vs 7.3 ± 2.8 days, respectively; $P = .005$,[44] and 8.1 ± 3.3 vs 13.9 ± 4.1 days, respectively; $P < .01$).[43] Finally, Routsi et al[52] randomly assigned 140 ICU patients to either a 55-minute daily EMS to both lower extremities or to a control group that did not get EMS. The intervention resulted in a significant reduction in the duration of ventilator weaning as well as an improvement (increase) in ventilator-free days. As with exercises such as in-bed cycling,[41] the targeted stimulation and exercise of skeletal muscle groups not directly involved in breathing may have provided systemic benefits that reduce critical illness polymyoneuropathy (CIPMN).[52]

In summary, there is uncertainty about the effect of an early physiotherapy intervention on the duration of MV in non-burn ICU patients. A small number of studies have reported benefits, but most studies have found no effect on the duration of MV or ventilator-free days. Heterogeneity in the intervention and control approaches as well as in the study population are important factors to consider and are likely responsible for the disparity in findings for this outcome.

The outcome of ICUAW has also been evaluated in many RCTs involving non-burn patients in the ICU, using numerous outcome measures including the Medical Research Council Sum Score (MRC-SS),[38, 39, 42, 45, 46, 52] proportion developing ICUAW,[38, 40, 45, 50] time needed to walk,[38, 45, 46] Six-Minute Walk Test (6MWT),[40, 41, 46, 55] SF-36 physical function (SF-36 PF) score,[40, 42, 46, 48, 54] BI,[38, 56] Physical Function in the ICU Test (PFIT),[40, 42, 45] Timed Up and Go (TUG) test,[40, 49] distance walked without assistance,[38] and the ability to walk independently.[38, 41] Several systematic reviews and meta-analyses of these RCTs have been conducted[1, 9–14] to examine the effects of EMR on many of these outcome measures. Some meta-analyses did not find any effect of the early mobilization intervention on peripheral muscle strength (eg, measured by MRC-SS,[1, 13] or incidence of ICUAW[1]) or physical function (eg, measured by PFIT)[10, 13] but did show the intervention improved walking without assistance at hospital discharge.[13] Conversely, other meta-analyses did find evidence that an early mobilization and physiotherapy intervention led to better short-term peripheral muscle strength (eg, measured by MRC-SS score,[11, 12, 14] or incidence of ICUAW[11]) and greater physical function (eg, measured by SF-36,[1] time to walking,[1] walking without assistance at hospital discharge,[12] or BI).[14]

There are several reasons for these discrepancies. Examination of a specific outcome such as the MRC-SS is illustrative: Among six RCTs that measured the MRC-SS,[38, 39, 42, 45, 46, 52] two studies found that the early physiotherapy intervention produced significant improvement in MRC-SS,[39, 52] while four studies found no effect of the intervention compared with control.[38, 42, 45, 46] However, one study compared systematic early mobilization to late mobilization,[38] four studies compared systematic early to standard early mobilization,[39, 42, 45, 46] and one study compared the early physiotherapy intervention to no intervention.[52] The physiotherapy interventions differed markedly between studies. One study used active and passive ROM, activities of daily living (ADL), and transfers to sitting and walking,[38] while another included in-bed leg cycle ergometry,[39] while yet another included upper and lower extremity cycle ergometry,[42] and one study used only EMS.[52] The "dose" of the intervention was not clear in all instances. Similarly, the comparator used in the control group was not always clearly described and varied between "conventional" therapy, "standard care," passive movement only, or no therapy intervention. Finally, the MRC-SS was measured at ICU discharge in five studies[38, 39, 42, 45, 46] but during the ICU stay in one.[52] Certainty in the overall quality of the evidence for this outcome is considered low to very low,[1, 10] due to lack of blinding of subjects and evaluators, heterogeneity of the intervention, and variability in the comparators. Thus, with respect to this one measure of ICUAW, it is difficult to reach any reliable conclusion on the effect of EMR. The aforementioned problems recur when other outcome measures of ICUAW and physical function are examined.

Therefore, at the present time, there is uncertainty about the effect of EMR on the development of ICUAW among

non-burn ICU patients. The timing of the intervention must be carefully considered; systematic early mobilization appears to be effective when compared with late mobilization in improving physical function (measured by SF-36 PF, proportion of patients reaching independence, and time needed to walk), but not when compared with "standard" early mobilization.[1] The composition and "dose" of the intervention need to be considered as does the nature and timing of the comparator. The difference in the timing of the intervention and comparator may be as important as when the intervention starts after ICU admission.[1]

Recommendation:

(a) Duration of MV:

No recommendation. At the present time, there is insufficient evidence to make a recommendation to initiate EMR to reduce the duration of MV in critically ill adult burn patients in an ICU setting.

Rationale and Considerations: There is no available scientific evidence in the burn literature, which directly examines the effect of EMR on the duration of MV. There is uncertainty about the effect of EMR on the duration of MV in the non-burn ICU literature. Taken together, we do not have confidence in the strength of the scientific literature to recommend EMR to shorten the duration of MV among critically ill burn patients in the ICU.

(b) ICU-acquired weakness

We conditionally recommend that EMR be initiated to reduce ICUAW among critically ill adult burn patients in an ICU setting.

Rationale and *c*onsiderations: Low- to very-low-quality evidence in a small number of studies in the burn literature suggests a possible beneficial effect of EMR on reducing ICUAW among critically ill burn patients. While there is some uncertainty in the non-burn ICU literature about the effect of EMR on the development of ICUAW, we have greater confidence that this intervention may help to diminish ICUAW in that population. The earlier intervention appears to be the most important consideration. There appears to be no signal of harm (see Safety and Barriers to Implementation section), but we recommend that when early mobilization is undertaken that it is done with open dialogue between the medical, nursing, and rehabilitation staff to identify any specific safety concerns or medical/surgical limitations.

Question 2: Among critically ill burn patients in an intensive care setting, does EMR, compared to nonstandardized or late mobilization and rehabilitation, result in fewer hospital-acquired pressure injuries?

For this question, we specified a population of adults > 18 years old with burns in an intensive care setting requiring invasive or noninvasive ventilation. We defined "early mobilization and rehabilitation" as any specified or protocolized active mobilization to sitting at bedside or standing or walking, which starts within the first 7 days post-injury. "Early mobilization and rehabilitation" for the purpose of this question does not include routine turning schedules or passive mobilization and stretching to prevent burn-related joint contractures. The comparison could include an absent, undefined, or non-protocolized mobilizing schedule or mobilizing after 7 days post-injury. The outcome of interest was the development of a hospital-acquired pressure injury (HAPI) of any stage (I–IV) in the first 3 weeks postburn injury. We selected 7 days as opposed to 14 days as the cutoff to initiate EMR because we believe that commencement of EMR after 7 days, while still relatively "early," would likely not be early enough to affect the development of a HAPI.

Pressure injuries, also referred to as "pressure sores," "pressure ulcers," or "bedsores" occur when external pressure on the skin, and less frequently shear on the skin, causes ischemic breakdown of the skin and underlying soft tissues to create a wound or ulcer. When pressure injuries occur in hospitalized patients, they are referred to as HAPIs. HAPIs are reportable adverse events that increase healthcare costs and in some cases result in financial penalties to hospitals.[57] The estimated prevalence of pressure injuries among patients in the ICU is 16.9 to 23.8%.[58] A point prevalence study among ICU patients in France found a prevalence of pressure injuries of 18.7%, with newly acquired HAPIs having a prevalence of 12.5%.[58] While the incidence and prevalence of HAPIs have not been widely examined in patients with burns in an intensive care setting, burn patients may be at even higher risk of HAPIs due to several unique risk factors: prolonged bedrest, LOS and MV, significant edema formation during resuscitation, progressive weight loss from hypercatabolism, loss of skin integrity and excessive moisture contacting the skin, splinting, multiple surgical procedures with postoperative immobilization orders, and substantial analgesia and sedation requirements.[59,60] A retrospective study estimated the incidence of pressure injuries to be 6.9% among burn patients admitted to the ICU.[59]

The literature on mobilization and HAPI reduction in critically ill burn patients is sparse. None of the studies selected for formal review from our search identified pressure injuries as an outcome. However, the study by Clark et al[34] (which we did not include because its study population consisted of 90% blunt or penetrating trauma cases and only 10% burn cases, without sub-analysis of the burns) did assess "pressure ulcers" before and after institution of an EMP. The incidence of pressure ulcers did not change significantly from before the EMP (7%) to after the EMP (7.3%).[34]

In the non-burn ICU literature, a recent systematic review and meta-analysis found no effect of EMPs on the development of pressure injuries in critically ill patients (OR 0.97; 95% CI: 0.49 to 1.91).[61] Four of the five studies in that meta-analysis were considered to have moderate to serious risk of bias, and none were RCTs.[61] An earlier meta-analysis of 15 RCTs involving "early mobilization and rehabilitation" of patients in the ICU assessed four trials for the outcome of "pressure sore" development. "Early rehabilitation" compared with "standard physical care" or "daily nursing care" was associated with a decreased risk of pressure sore reduction (RR 0.14; 95% CI: 0.04, 0.44; $P = .001$)[62] *.

It is important to distinguish regular turning schedules from an EMR program. The former would be considered standard care, while the latter is the main intervention of interest in this CPG. Since it would be unethical to study "no turning" compared with a protocolized turning regimen, most of the literature on patient turning and HAPI development in

critically ill patients concentrates on comparisons of different intervals of patient turning or alternative patient positioning approaches. A Cochran systematic review found that the effect on HAPI development of two-hourly vs three-hourly vs four-hourly turning schedules was uncertain, as was the effect of 30° vs 90° tilt positioning, again due to low confidence in the literature quality.[63] In summary, there is uncertainty, mainly from a distinct lack of scientific studies, on the effect of EMR on the development of HAPIs in critically ill burn patients.[63]

*The four studies used to conduct this meta-analysis on the outcome of HAPI development were not specifically identified in the text and no Forest plot was shown. Hence, details of the individual RCTs cannot be provided and remain uncertain.

Recommendation:

No recommendation. At the present time, there is insufficient evidence to make a recommendation to initiate EMR to reduce the development of HAPIs among critically ill adult burn patients in an ICU setting.

Rationale and Considerations: We were unable to identify any interventional studies specifically among critically ill burn patients on the effect of EMR on HAPI development. Among non-burn ICU patients, we have low confidence in the available literature to recommend EMR to reduce HAPIs. EMR must be distinguished from the important process of regular passive turning and position changes of an ICU patient. The latter was not evaluated as part of this guideline, and institutions should continue to follow their existing guidelines on this intervention.

> *Question 3. Among critically ill burn patients in an intensive care setting, does early mobilization and rehabilitation (EMR), compared with nonstandardized or late mobilization and rehabilitation, result in loss of skin grafts or skin substitutes?*

For this question, EMR is defined as any physical or occupational therapy that involves muscle activation or mobilization from recumbent or semi-recumbent position to sitting, standing, or walking within 14 days of burn injury. This would be performed according to a clearly defined protocol or criteria. "Early mobilization and rehabilitation" for this question does not include passive mobilization and stretching to prevent joint contractures. The comparator for this question could include no mobilization, any undefined or nonstandardized mobilization program, or "standard" mobilization or mobilizing after 14 days. Two main outcomes were identified for this intervention: 1) loss or disruption of skin grafts or skin substitutes requiring reoperation or reapplication and 2) loss or disruption of skin grafts or skin substitutes not requiring reoperation or reapplication. We selected 14 days as opposed to 7 days as the cutoff to initiate EMR to capture more grafting operations. In a major critically ill burn patient, all grafting (with autologous skin, allograft, or skin substitutes) may not have been completed by day 7.

On review of the literature, none of the studies addressing these outcomes of interest met all four criteria and, therefore, did not undergo formal review for inclusion in the practice guideline. Given the lack of high-quality studies specifically involving critically ill burn patients and the effects of early rehabilitation and mobilization on the viability of skin grafts and skin substitutes, available literature on the mobilization of burn patients with skin grafts was reviewed. All of the studies described involved some form of early mobilization, but some described mixed patient populations, some did not involve patients in the ICU setting, and some did not have a comparator group. Still, these studies offer insight and direction for future studies and may be of value in understanding the effects of early mobilization on skin grafts and skin substitutes in the burn population.

Clark et al[34] conducted a retrospective case–control study of 2176 patients of which 10% were burns (% TBSA burn and inhalation injury not reported), and 75% were blunt trauma, with no sub-analysis of the burn patients. The authors identified no change in complication rate in the "musculoskeletal/integumentary" category with the initiation of a progressive mobilization protocol (10.7% vs 10.8%; $P = .93$), though the exact nature of the complications considered as "integumentary" was not specified. Tan et al[64] reviewed their experience with 108 burn patients who sustained TBSA burns in excess of 50% who received early rehabilitation, looking for an association with contracture formation. While the authors delineated their graduated rehabilitation plan in detail, no comparison group was available to assess the stated outcomes. The authors concluded that extended rehabilitation days increased the number of moderate contractures relative to severe contractures. Although severe contracture could have been related to graft loss and poor healing, this study did not provide enough detail to draw conclusions about the impact on skin graft adherence from early rehabilitation. Schmitt et al[65] reported their experience with mobilization in a set of patients with burn injury who received a novel dermal substitute. This case series included a range of patients from 2 to 75% TBSA with an ICU LOS 0 to 68 days and acute hospital LOS of 9 to 258 days. The analysis was not strictly limited to our patient population of interest, and no comparison group was available. The authors clearly delineated their graduated rehabilitation plan in detail and reported that clearance for mobility occurred at a mean of 10.4 and 4.9 days after dermal substitute and after skin graft application to lower limbs, respectively. They found no reported incidents where physical therapy interfered with dermal substitute integration or split-thickness skin graft take and reported no adverse events related to physical therapy; however, no additional data were provided.

ABA Practice Guidelines written by Nedelec et al in 2012 discussed early ambulation after lower extremity grafting.[66] They reviewed literature from 16 studies spanning 1969 to 2009, with early mobilization defined as early as 24-h post-grafting, and concluding that there was no signal that graft loss occurred with early mobilization, regardless of whether patients underwent grafting for burn or non-burn reasons. One of the limitations of this practice guideline was noted to be the lack of data for burn wound sizes greater than 300 cm^2 which could include those more likely to be in the intensive care unit for large surface area cutaneous injury.

Lorello et al[67] conducted an RCT to evaluate the risk of graft failure in patients with burn injury receiving early mobility (EAG) and standard therapy (ST) after lower extremity skin grafting. Although this study specifically addresses the impact of early mobilization on skin grafts, it was not included in the formal review because the patients were not all

treated in the ICU. Thirty-one adults with small TBSA burns (3.59% in EAG and 4.07% in ST) were randomized to ambulate within 24 hours of surgery (EAG) or remain on bedrest postoperatively for 5 days (ST). There was no difference in the number of patients with graft loss in either group. In those patients who had graft loss, however, the standard group had a higher percentage of loss of the graft (EAG 1.0%, STG 7.7%; $P = .0376$). Although this study looks at small burns in noncritically ill patients, it offers some support for early mobilization without significant graft failure.

Franczyk et al[68] retrospectively evaluated adherence of skin grafts applied in conjunction with sub-atmospheric pressure wound therapy (SAWT) for patients who received gait training on post-operative day (POD) #2 as part of a standard protocol. This study was not included in the formal review because only 26% of the patients had burn injury and there was no comparator group. The mean surface area grafted for 154 patients reviewed was 172 cm^2. The authors reported that none of the patients experienced graft loss or fluid collection with the removal of SAWT. In addition, none of the patients returned to the operating room for additional debridement or grafting because of early mobilization, and most patients were discharged by POD #5 (83%). Other small retrospective studies of patients with lower extremity grafts have also found no adverse effects from early mobilization.[69,70]

Finally, Retrouvey et al[71] conducted a systematic review and meta-analysis evaluating the impact of early vs late mobilization after split thickness skin graft (STSG) in adult patients with extremity wounds. Seven studies were included for review, two of the three that defined the patient population included burns. Early mobilization occurred within 3 days of surgery, whereas late mobilization was defined as occurring 4 or more days after surgery. No statistically significant difference was found for the number of grafts lost or the percentage of graft take between early and late mobilization. The findings of this systematic review and meta-analysis support the postulation that early mobilization does not detrimentally impact wound healing. However, again, because the analysis was conducted with more than the burn population and it is uncertain if the burn patients were critically ill, further burn ICU patient population-specific work is needed. Intriguingly, the same data analysis identified a trend toward less deconditioning with early mobilization, a finding with significant implications for outcomes after critical illness.

In summary, there is no clear consensus about the effect of an early physiotherapy intervention on graft outcomes in critically ill burn patients. No studies have been completed in the ICU setting, though extrapolation of studies and guidelines from the general burn and wound populations would suggest that early mobilization is safe for skin grafts and skin substitutes.

Recommendation:

No recommendation. At the present time, there is insufficient evidence to determine whether EMR leads to skin graft or skin substitute loss among critically ill adult burn patients in an ICU setting. We suggest that surgeons and rehabilitation therapists consider whether early mobilization is feasible and warranted in a critically ill burn patient with recent grafting, taking into consideration surgeon preference along with the size and extent of the skin graft or substitute.

Rationale and Considerations: There does not appear to be any evidence that mobilization causes harm to skin grafts and skin substitutes in burn patients outside of an ICU setting, but the effect of early mobilization on this outcome in critically ill burn patients in the ICU has not been specifically examined.

Question 4. Among critically ill burn patients in an intensive care setting, does EMR, compared to nonstandardized or late mobilization and rehabilitation, reduce the prevalence of delirium?

For this question, we defined EMR as any physical or occupational therapy that involves muscle activation or mobilization from recumbent or semi-recumbent position to sitting, standing, or walking or within 7 days of burn injury even if receiving MV. This would be performed according to a clearly defined protocol or criteria. The comparator for this question could include no mobilization, any undefined or nonstandardized mobilization program, or "standard" mobilization or mobilizing after 7 days. We identified three main outcomes for this intervention: 1) the presence or absence of delirium as a binary variable, 2) the number of hospital days with delirium, and 3) the percentage of time experiencing delirium. We selected 7 days as opposed to 14 days as the cutoff to initiate EMR because we believe that commencement of EMR after 7 days, while still relatively "early", would not be early enough to affect the selected outcome measures.

No interventional studies were identified that evaluated the effects of EMR in critically ill burn patients on our outcomes of interest related to delirium.

Given the lack of studies involving critically ill burn patients on the effects of early rehabilitation and mobilization on delirium, we reviewed literature from the general medicine and medical ICU (MICU) populations.

Delirium is defined as a serious disturbance in mental abilities that results in confused thinking and reduced awareness. Development of delirium may have one or more contributing factors, such as a severe or chronic illness, electrolyte disturbances, medications, infections, operations, and alcohol or drug intoxication or withdrawal.[72] Multiple studies have examined risk factors for delirium. A single factor rarely causes delirium to occur, whereas the more risk factors a patient has the higher the likelihood of developing delirium.[73–76] Immobility has been identified as a potentially modifiable risk factor for the development of delirium and became a target for possible interventions to prevent delirium.[38,77–80]

One of the first studies looking at the importance of mobility on the development of delirium was completed by Inouye et al.[81] A multicomponent intervention was compared with usual treatment in patients admitted to a general medicine service. The intervention addressed six risk factors for delirium: cognitive impairment, sleep deprivation, immobility, visual impairment, hearing impairment, and dehydration. The primary outcome was the development of delirium as assessed daily using the Confusion Assessment Method (CAM). The intervention in this study for immobility was ambulation or active ROM exercises three times daily as well as limiting immobilizing equipment such as bladder catheters and restraints. The intervention group had an incidence of delirium which was significantly lower than in the usual-care

group (9.9 vs 15.0%, $P = .02$). The intervention reduced the likelihood of developing delirium (OR 0.6; 95% CI: 0.39 to 0.92), and the total number of days of delirium was significantly lower in the intervention group (105 vs 161 days; $P = .02$) as was the total number of episodes of delirium (62 episodes vs 90 in the usual-care group; $P = .03$).

The effects of mobility on the development of delirium in the ICU have been studied. Schweickert et al[38] sought to examine the efficacy of combining daily interruption of sedation with physical and occupational therapy on functional outcomes in patients receiving MV to assess both functional outcomes and ICU-associated delirium. Mechanically ventilated patients were randomly assigned to either an enhanced exercise and mobilization intervention or standard of care. The intervention involved a stepwise therapy program starting with passive ROM exercises, then progressing to active ROM exercises while supine then sitting, and finally working toward independence with ADLs and functional tasks. Patients were assessed daily using the Confusion Assessment Method for the ICU (CAM-ICU) for delirium and coma. Patients in the intervention group ($N = 49$) had fewer days with ICU delirium (2 vs 4 days; $P = .03$), and shorter percent of time in ICU with delirium (33 vs 57%; $P = .02$) than the standard of care patients.

Needham et al[79] conducted a before/after quality improvement project in MICU patients. Prior to implementing changes, patients were placed on bed rest without any standardized physical or occupational therapy program. The changes to their standard of care included increasing activity to "as tolerated," decreasing the use of continuous infusions of benzodiazepines and opioids, establishing guidelines for physical and occupational providing full-time therapists, and use of physiatry and neurology consultants when appropriate. Post-intervention, there was a significant decrease in the percentage of patients who were classified as delirious by the CAM-ICU score (28 vs 36%; $P = .003$).

The Society of Critical Care Medicine (SCCM) created an "ABCDE bundle" which incorporates mobility as a prevention for delirium.[82, 83] The ABCDE bundle refers to: *A*wakening and *B*reathing *C*oordination, *D*elirium monitoring/management, and *E*arly exercise/mobility. The bundle was developed to reduce exposure to MV and sedatives while encouraging mobility with the goal of preventing delirium.[84–87] Balas et al[88] performed a prospective before–after cohort safety and effectiveness study utilizing the ABCDE bundle in multiple ICUs at a single institution. They recruited a total of 296 patients (146 pre-implementation and 150 post-implementation) irrespective of MV status. The pre-implementation patients received standard of care, whereas post-implementation patients underwent protocolized spontaneous awakening trials (SATs), spontaneous breathing trials (SBTs), daily monitoring of sedation/agitation levels and delirium, and mobilization at least once a day, including sitting on edge of bed, standing at the bedside, sitting in a chair, and walking a short distance.

Prior to implementation, only 48% of patients were mobilized compared with 66% after implementation ($P = .002$). Following implementation of the ABCDE bundle, the percentage of patients who experienced delirium was reduced (pre 62.3 vs post 48.7%; $P = .02$). Overall, the duration of delirium decreased by one day post-implementation, and the percent of ICU days spent delirious decreased by 17% (50% [IQR 30–64.3] vs 33.3% [IQR 18.8–50]; $P = .003$). Multivariable regression found that the ABCDE was associated with significantly less delirium (OR 0.55; 95% CI: 0.33 to 0.93; $P = .03$).

The ABCDE bundle was revised to the ABCDEF bundle in 2014. The new bundle included: *A*ssess, Prevent, and Manage Pain; *B*oth SATs and SBTs; *C*hoice of Analgesia and Sedation; *D*elirium: Assess, Prevent, and Manage; *E*arly Mobility and Exercise; and *F*amily Engagement and Empowerment.[89] A multicenter, cohort study[90] enrolled 15,226 ICU patients and looked at the results of the bundle with respect to "complete performance," which was defined as a patient-day in which every eligible element of the bundle was performed, and with respect to "proportional performance," which was defined as the percentage of eligible elements a patient received on a given day. When the complete ABCDEF bundle was performed, there was a lower likelihood of delirium (adjusted odds ratio of 0.60; 95% CI: 0.49 to 0.72; $P < .00010$). Additionally, when the proportional performance of the bundle was investigated, they found that a higher proportion of eligible ABCDEF bundle elements performed on a given day was associated with a significantly decreased likelihood of delirium, ($P < .0001$).

In summary, while there are no studies that examine the effects of mobility on delirium in the burn ICU literature, in the critical care population, a small number of studies have shown the benefit of mobility in the ICU as a stand-alone prevention for delirium. There is some heterogeneity in the interventions that are provided in these studies, but they all increase the amount of activity that patients in the ICU are receiving. In addition, there have been several studies that examine the ability of mobility in combination with other risk factor mitigation protocols that have been shown to decrease the development of delirium in ICU patients. Thus, there is reasonably consistent evidence that early mobility (both alone and in connection with other strategies) in ICU patients is a safe and effective prevention strategy for delirium.

Recommendation:

We conditionally recommend that EMR be initiated to reduce delirium among critically ill adult burn patients in an ICU setting.

Rationale and *C*onsiderations: Although we were unable to identify any studies on the effect of EMR on the development of delirium in critically ill burn patients, we have confidence in the effect of this intervention, as part of an ABCDEF bundle, on reducing delirium in the non-burn ICU population. Again, good communication between the medical, rehabilitation, and nursing staff is mandatory to determine whether early mobilization is safe and feasible in an individual critically ill burn patient (see Safety and Barriers to Implementation section).

SAFETY AND BARRIERS TO IMPLEMENTATION

Although we did not formally examine complications or adverse effects related to EMR as an outcome, it is important to consider the safety of and barriers to implementation of this intervention. While the concept of EMR in an ICU setting is

not new, survey data suggest wide variation in the application of this intervention. Among critically ill burn patients, a survey of six high-volume burn centers in the United States reported substantial variability in the frequency, intensity, and duration of various isometric, isotonic, aerobic, and resistive exercises.[30] While mobilization out of bed was used as a type of exercise in all six burn centers, only four centers reported ambulating intubated patients.[30] A 2021 survey of 63 burn rehabilitation therapists and nurses from multiple North American burn centers found that 54% mobilize ventilated patients out of bed, and 50% mobilize patients on vasopressor support. The presence of vascular catheters, mode of ventilation, mental status, and vital signs were the most important precautionary factors to be reviewed with the medical team prior to mobilizing a patient.[91] Among non-burn ICU patients, a survey of 194 critical care physicians and 117 physiotherapists in Canada[92] revealed that 69% underestimated the incidence of ICUAW and 60% felt they lacked the skill and knowledge to mobilize a patient on a ventilator. Interestingly, the physiotherapists (PTs) were more likely than the physicians (MDs) to consider early mobilization crucial or very important. The most common perceived barrier to early mobilization in the ICU was patient medical instability (91% of PTs, 77% of MDs), followed by excessive sedation (64% of PTs, 58% of MDs), risk of dislodgement of lines or devices (21% of PTs, 55% of MDs), obesity (26% of PTs, 37% of MDs), and cognitive impairment (22% of PTs vs 37% of MDs). Surprisingly, endotracheal intubation was the sixth most common perceived barrier (15% of PTs, 37% of MDs).

Adverse events during early mobilization in the ICU appear to be uncommon. One systematic review and meta-analysis of EMR in ICU patients[12] involving 14 randomized or controlled clinical trials (1753 patients) identified only one study that reported a serious adverse event (oxygen desaturation < 80% in 1/498 [0.2%] of mobilization sessions).[38] Six studies reported adverse events during the intervention, including cessation of the session due to patient medical instability (4% of sessions),[38] orthostatic hypotension in 11% of patients in one study[50] and 3% of patients in another,[44] syncope in one patient (2%),[54] dislodgement of an arterial line in one patient (1%) in one study[50] and in 1% of sessions in another study,[38] loss of a nasogastric tube in one patient (1%),[50] oxygen desaturation less than 90% in two patients (2%),[50] and one episode of asymptomatic bradycardia (one patient, 1%).[54] Several RCTs of early mobilization reported no episodes of endotracheal tube dislodgement.[38, 44, 48, 50, 54] A Cochrane systematic review[10] of four RCTs of early mobilization or active exercise in critically ill adults (690 patients)[38, 42, 48, 93] had low certainty in the evidence regarding adverse events due to the low frequency of these events, which occurred in 2 to 5% of patients in the intervention arms of the included studies.

While it seems that adverse events are infrequent, there are some unique considerations for burn patients in the ICU. Inadvertent loss of the airway could be catastrophic in a patient with significant burn-related facial and neck edema. Thus, the threshold for mobilization might be higher in some intubated burn patients compared with the average medical–surgical ICU patient. The same rationale applies to the loss of vascular catheters in burn patients who may have limited sites for access due to wounds, grafts, and dressings. Burn surgeons may not want patients with fresh lower extremity skin grafts to be mobilized for at least 3 to 5 days postoperatively.[30] Burn patients are frequently more heavily sedated due to pain from extensive wounds, relative to non-burn patients in the ICU.

Thus, medical clearance to mobilize a burn patient in the ICU is of utmost importance and must involve good dialog between the medical/surgical, rehabilitation, and nursing staff. Most importantly, the success of implementing an EMR program in the burn ICU rests upon developing a realistic and practical protocol, having adequate resources for education, training, and implementation, advocates who support the intervention, and a unit "milieu" or "culture," which recognizes the importance and limitations of the intervention.[94]

OPPORTUNITIES FOR FURTHER RESEARCH

This guideline has uncovered a deficiency in studies of the effects of EMR among critically ill burn patients in an ICU setting. The CPG ad hoc Committee identified the following potential areas for scientific investigation:

- Metrics to define and measure ICUAW in critically ill burn patients have not been widely examined. There is a need for a common set of measurements to identify and study ICUAW.
- Well-defined EMR protocols have not been studied in comparison to "standard therapy" or later mobilization and rehabilitation with respect to the outcome of duration of MV in critically ill burn patients.
- Observational studies to assess the safety and adverse effects (eg, graft loss) of early mobilization in critically ill burn patients in the ICU are needed.
- The effect of a defined EMR protocol during the critical illness phase on the development of HAPIs during the entire hospital stay has not been studied.
- The effect of EMR, as part of an ABCDEF bundle in critically ill burn patients, on the outcome of delirium development needs to be examined.

QUALITY AND PERFORMANCE MEASURES

This guideline has conditionally recommended that EMR be considered in critically ill burn patients in the ICU to reduce ICUAW and delirium. No recommendation could be formed regarding the outcomes of HAPI development or skin graft loss. Despite the relatively "weak" recommendations and need for further study, burn care facilities may wish to collect and compare data on certain benchmarks to measure the use of EMR for burn-ICU patients. We stress that such benchmarks should not be considered definitive standards of care to determine reimbursement but rather should be used as measures of performance and to improve quality of care. While refinement of definitions for "critically ill" and "mobilization" is needed, possible measures might include:

- Proportion of critically ill burn patients in the ICU who are mobilized within the first 7 days following injury.
- Frequency and duration of mobilization sessions in each critically ill burn patient in the first 7 days after injury.

- Time from injury to mobilization in each critically ill burn patient.
- Maximum extent of mobilization of each critically ill burn patient in the first 7 days after injury.

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