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Early mobilization in the critical care unit: A review of adult and pediatric literature

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ABSTRACT

Early mobilization of critically ill patients is beneficial, suggesting that it should be incorporated into daily clinical practice. Early passive, active, and combined progressive mobilizations can be safely initiated in intensive care units (ICUs). Adult patients receiving early mobilization have fewer ventilator-dependent days, shorter ICU and hospital stays, and better functional outcomes. Pediatric ICU data are limited, but recent studies also suggest that early mobilization is achievable without increasing patient risk. In this review, we provide a current and comprehensive appraisal of ICU mobilization techniques in both adult and pediatric critically ill patients. Contraindications and perceived barriers to early mobilization, including cost and health care provider views, are identified. Methods of overcoming barriers to early mobilization and enhancing sustainability of mobilization programs are discussed. Optimization of patient outcomes will require further studies on mobilization timing and intensity, particularly within specific ICU populations.

Mobilization has been defined as "physical activity sufficient to elicit acute physiological effects that enhance ventilation, central and peripheral perfusion, circulation, muscle metabolism and alertness and are countermeasures for venous stasis and deep vein thrombosis" [1]. A current definition of *early mobilization* refers to the application of physical activity within the first 2 to 5 days of critical illness or injury [2]; however, it is important to note that some of the research published on "early" mobilization is beyond this window. For example, one study defined *early intervention* as an activity beginning before intensive care unit (ICU) discharge (6.6 ± 5.5 days for sitting on bed) [3]. Delaying mobilization until the acute phase of illness has subsided may not only significantly decrease benefit but also result in less optimal patient outcomes. The goals of this review are to (1) emphasize the practicality and effectiveness of early mobilization and its impact on recovery from a critical illness in both adults and children and (2) highlight the many perceived barriers to early mobilization, such as cost, health care professional views, and sustainability.

1. Consequences of immobility in the critically ill

Typical critical care interventions that promote immobilization include the administration of analgesics and sedatives to facilitate mechanical ventilation and reduce pain, agitation, and/or anxiety [4,5]. Immobility is associated with ICU delirium, impaired exercise capacity, ICU-acquired weakness (ICU-AW), and poorer functional outcomes and quality of life [6,7]. Intensive care unit–acquired weakness is categorized by both axonal nerve degeneration and myosin loss, and is believed to be the multifactorial result of systemic inflammation, medications, electrolyte disturbances, and immobility [8,9].

Immobility-associated muscle loss begins within 48 hours of critical illness onset or injury [10] and is greatest during the first 2 to 3 weeks of an ICU stay [11]. Up to a 40% loss in muscle strength can occur within the first week of immobilization, with a daily rate of strength loss between 1.0% and 5.5% [6,12]. A 10.3% to 13.9% decrease in cross-sectional measurements of the rectus femoris muscle has been observed within the

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first ICU week and is positively correlated with elevated C-reactive protein levels and organ dysfunction severity [13,14]. Diaphragmatic atrophy due to ventilator-induced diaphragm inactivity during positive pressure ventilation is positively correlated with the severity of limb weakness (maximal inspiratory pressure $\rho = 0.35$, $P = .001$; maximal expiratory pressure $\rho = 0.49$, $P < .0001$; vital capacity $\rho = 0.31$, $P = .007$) [15]. Its severity is associated with duration of mechanical ventilation [15–18]. Clinical phenotypes of ICU-AW have been described that may predict nerve and muscle functional recovery and are determined through a combination of factors including increased age, comorbidity, ICU length of stay (LOS), and additional risk differentiators such as cognitive dysfunction [19].

Intensive care unit–acquired weakness affects 25% to 100% of critically ill adult patients [20–22], whereas the incidence of ICU-AW is less frequently reported in the pediatric ICU (PICU) population, likely because of the lack of a feasible and reliable screening tool. In a recent pediatric pilot study, ICU-AW was confirmed in 6.7% of "at-risk" patients and suspected in 30% [23]. Intensive care unit–acquired weakness is age dependent, with 0.7% of very young children and 5.1% of older children exhibiting muscle weakness [23,24].

Intensive care unit–acquired weakness is an independent predictor of mechanical ventilation duration and is associated with longer ICU and hospital stays [9,21]. A 40% loss of lean muscle mass approaches a mortality rate of 100% [25]. Muscle wasting, exercise intolerance, and decreased quality of life ratings persist 1 year post–ICU discharge in affected adult and pediatric survivors [8,20,24,26,27]. Persistent functional impairment and perceived muscle weakness are reported on a 5-year examination of functional outcomes in adult ICU survivors; these outcomes appear to plateau at 1 year, with patients making little substantial gains after that time [27]. Long-term functional outcomes are less clear in pediatric patients and have not been studied prospectively to date.

2. Early mobilization in critically ill patients

Research on early mobilization is growing in the adult population, whereas studies in the pediatric population are still in their infancy. Thirteen prospective studies have been conducted in adults [3,28–39], but only 3 are randomized controlled trials [30,34,39]. A recent Canadian survey, composed of 198 adult ICUs, indicated that although 71% of the units prioritized early mobilization, only 38% of the ICUs had mobilization protocols. Furthermore, only 31% of adult ICUs had access to specialized equipment for the purpose of early mobilization therapies [40].

The most common types of rehabilitation techniques administered in Canadian adult ICUs are functional mobility retraining and therapeutic exercises [41]. Not surprisingly, the majority of early mobilization research has focused on active, rather than passive, therapies. Among critically ill children, rehabilitation is primarily focused on nonmobility interventions, most commonly chest physiotherapy, and only 9.5% receive early mobilization [42,43].

Early mobilization is part of the Awakening and Breathing Coordination, Delirium monitoring/management, and Early exercise/mobility (ABCDE) bundle [44–46]. The bundle approach combines a number of evidence-based patient care interventions with the goal of increasing focus on the aforementioned areas of concern and improving patient outcomes [47]. Specifically, the goal of the ABCDE bundle is to increase liberation from mechanical ventilation, facilitate earlier ICU and hospital discharge, aid in the return to normal brain function, improve independent functional status, and increase patient survival [45]. Some of the ABCDE bundle components have been independently evaluated. The Awake and Breathing Controlled Trial demonstrated the effectiveness of spontaneous awakening and spontaneous breathing trials for decreasing ICU and hospital LOS. It also demonstrated a decrease in 1-year mortality [46]. The creation of delirium screening tools and the identification of sedative medications as modifiable risk factors for delirium have prompted increased deliberation regarding the types of medications and have encouraged the practice of sedation vacations [46]. The bundle provides an all-or-nothing concept, from which physicians are able to withdraw if clinically indicated [44,47]. Research has shown the ABCDE bundle to be safe and effective. Spontaneous awakening and breathing trials are more likely to occur (50% post–intervention initiation vs 25%, $P = .001$; 84% post–intervention initiation vs 71%, $P = .03$, respectively), and there is an increased likelihood of mobilization in the ICU (2.11; 95% confidence interval, 1.30-3.45; $P = .003$) [44]. Furthermore, the incidence of delirium is reduced following implementation of the ABCDE bundle (48.7% post–intervention initiation vs 62.3%, $P = .02$) [44].

2.1. Active mobilization

Active mobilization in ICU patients is thought to be effective and is recommended in international guidelines [1]. A variety of active mobilization protocols have been utilized, including active or resistive range of motion (ROM) exercises, sitting on a bed or chair, bed exercise (eg, cycling), dangling, transfers, tilting up (arms supported or unsupported), and ambulating (either assisted or unassisted) [3,29,30,35,37,38]. Early mobilization can be safely initiated on the first day of ICU admission and even during mechanical ventilation [29,35], administration of vasopressors [32,39,48], continuous renal replacement therapy (CRRT) [49,50], and with femoral catheters in situ [51,52]. The rate of adverse events ranges between 0% and 3%, and the reported adverse events are not usually serious [3,29,30,35,37,38]. Adverse events typically include cardiovascular events, falls, or tube extractions (Table 1). The adverse events rarely require additional treatment or result in additional cost or LOS [35]. Ambulation distance at ICU discharge was increased in patients who received early active mobilization in the ICU [3] compared with patients for whom mobilization is initiated after ICU discharge [53].

In a retrospective pediatric study including 600 children (mean age = 4.9 years) with primarily medical diagnoses (64.2%), a significantly greater duration of vasoactive medication infusion, PICU LOS, and delirium was present in mobilized patients. Although this may suggest a negative effect of mobilization, the authors postulate that clinicians were inadvertently selecting sicker patients [42].

2.2. Passive mobilization

Passive therapies, such as manual passive exercises, cycle ergometers, and/or continuous passive motion machines [28,39], may be used for patients unable to cooperate with instructions. Cycle ergometry training has been effectively used for passive, active-assisted, and/or active ROM exercise [39]. Continuous passive motion machines passively alternate leg movements to simulate slow walking as early as 38 hours following intubation [28]. Passive exercise is safe in mechanically ventilated adult patients. In one study, continuous passive motion did not have a negative impact on heart rate, blood pressure, or oxygen saturation; and only 16 (3.7%) of the 425 exercise sessions using the cycle ergometer ended prematurely because of an abnormal physiological response [28,39].

Although the safety of early passive exercise in ICU patients has been questioned out of concern for exercise-induced propagation of systemic inflammation [28], nonexhaustive exercise has been demonstrated to have antioxidant effects and to alter levels of inflammatory cytokines [54,55]. Passive exercise has been demonstrated to improve functional exercise capacity, improve perceived functional status, increase quadriceps muscle force, and decrease pain scores [28,39]. Regional limb blood flow is increased by passive exercise, as measured by ultrasound Doppler, because of changes in intramuscular pressure [56]. Passive activity for an average of 14.7 minutes in critically ill patients significantly decreased interleukin (IL)-6 levels and improved the cytokine balance (IL-6/IL-10 ratio), potentially improving recovery [28,57,59].