Objectives

- Describe post–intensive care syndrome (PICS).
- Discuss ways to prevent and treat PICS.

Key words: critical illness, post–intensive care syndrome, long-term impairments, screening

Advances in critical care medicine have led to improved outcomes; as a result, most patients will survive their critical illness episode. However, many survivors do not return to their pre–critical illness functional levels. Rather, survivors of critical illness often experience impairments in cognition, mental health, and physical health that endure. Research over the past 2 decades has increased our knowledge and awareness of these morbidities after critical illness. Post–intensive care syndrome (PICS), a term coined in 2012 to raise awareness of these impairments,\textsuperscript{1} is common after critical illness.

Specifically, 34% of patients who experience shock and/or require invasive mechanical ventilation experience cognitive impairment at 12 months at a level consistent with moderate traumatic brain injury.\textsuperscript{2} Symptoms of anxiety, depression, and/or posttraumatic stress disorder (PTSD) afflict approximately 25% of survivors of critical illness,\textsuperscript{3} and 27% of survivors are physically impaired at 1 year after critical illness.\textsuperscript{4} Together, 56% of survivors experience a new, enduring impairment in 1 or more of these domains, and 21% experience 2 or more impairments at 1 year.\textsuperscript{5} Similarly, findings from a small telephone-based study that used patient report of problems found that 54% of patients developed impairments and 56% of patients had 2 or more impairments after critical illness.\textsuperscript{6}

Related to the 3 domains that define PICS—impairments in cognition, mental health, and physical health—survivors experience a myriad of challenges and functional impairments, including pulmonary dysfunction, particularly among survivors of acute respiratory distress syndrome (ARDS);\textsuperscript{7} chronic pain;\textsuperscript{8} sexual dysfunction;\textsuperscript{9} and functional disability related to contractures.\textsuperscript{10} These impairments contribute to the reduced health-related quality of life that has been observed among survivors of critical illness as well as the inability to return to full-time employment.\textsuperscript{11}

OUTCOMES TRAJECTORIES

Impairments, when measured, are common at the time of ICU discharge. In one study, 34% of survivors were cognitively impaired to a mild to moderate degree, and an additional 50% were severely impaired 24 to 48 hours after ICU discharge.\textsuperscript{12} At hospital discharge, 64% of survivors were found to be cognitively impaired, when the Mini–Mental State Examination (MMSE) was used as a screening test, and 57% were impaired at 6 months when a formal neuropsychological test battery was used.\textsuperscript{13} However, cognitive screening tests at hospital discharge did not predict 6-month cognitive testing. Similarly, data for the ARDSNet Long Term Outcomes Study (ALTOS)
compared performance on the MMSE to a concurrently administered, detailed neuropsychological test battery. Agreement between the MMSE was fair and sensitivity was poor when compared with concurrently administered neuropsychological tests. These data highlight the importance of serial neuropsychological and physical screening assessments during recovery, paired with formal assessment in those who screen positive.

Although impairment is common after critical illness, 44% of survivors without preexisting impairments will be PICS-free at 12 months. Survivors who have higher educational attainment are more likely to be PICS-free, highlighting the importance of investing in education as a long-term priority to mitigate PICS in the decades ahead.

RISK FACTORS FOR PICS

As detailed in Figure 1, risk factors for long-term impairments after critical illness are multiple and include preexisting impairments (ie, frailty), critical illness itself (eg, inflammation, sepsis), its consequences (eg, immobilization), and therapies (eg, mechanical ventilation). Mechanical ventilation, commonly used in ICUs, has been associated with hippocampal apoptosis through vagal and dopaminergic pathways.

Other risk factors identified include hypoxemia, hypoglycemia, conservative fluid-management strategy, and duration of delirium. Because glucose and oxygen fuel essential brain functions, avoiding extreme depletions of these essential nutrients is a reasonable objective during critical illness to protect long-term brain health.

Given the relationship between early, deep sedation and adverse short- and long-term survival, potentially mediated through duration of delirium, strategies to prevent delirium, reduce its duration, and avoid excess sedation are warranted. Notably, concerns that light sedation practices could lead to neuropsychological harm are unfounded. In fact, light sedation has been shown either to not be harmful or to be potentially beneficial to mental health, as survivors enrolled in the daily sedation interruption and awakening arm of one study were observed to exhibit fewer symptoms of PTSD. Symptoms of PTSD, likewise, have been...
associated with excessive sedation and delusional memories. Strategies to facilitate formation of factual memories, such as the use of an ICU diary with a structured debriefing, have been associated with reduced symptoms of PTSD among survivors.27–29 Because ICU diaries appear to benefit the mental health of caregivers as well, family-centered care guidelines recommend the use of such diaries.30 Clinicians should be aware that corticosteroids, often used for shock reversal, have been found to reduce PTSD symptoms.31 The implications of unmitigated PTSD reach far beyond the psychological suffering of patients and families: In a prospective observational study of cardiac arrest survivors treated in an ICU, posttraumatic stress symptoms were associated with a significantly higher risk of death and cardiovascular events within 12 months of hospital discharge.32

FUNCTIONAL IMPAIRMENTS

As noted previously, physical, cognitive, and mental health impairments are associated with reduced quality of life, impairments in instrumental activities of daily living (IADLs), and inability to return to employment. Poor functional outcomes are common after critical illness and are associated with impairments in tasks required for living independently, such as managing finances and medications. A systematic review of 16 studies assessed IADLs in ICU survivors.33 Of the 16 studies, 11 reported that survivors had new and/or worsening dependencies in IADLs. No consistent risk factors were identified for new or worsening IADL dependencies across studies. The most common factors included older age, impairments in baseline IADLs, ICU delirium, and duration of mechanical ventilation. New or worsening IADL dependencies persisted for months after ICU discharge for most survivors. The relationship between IADL dependencies and cognitive impairments has not been studied in ICU populations, but in other populations these factors are associated.33 Intervention studies to improve IADL dependencies are also needed.

A national multicenter study of 922 previously employed survivors of ARDS found that 44% were jobless 12 months after ICU discharge.34 Longer hospitalization and older age among nonwhite survivors were associated with delays in return to work. Of ARDS survivors who returned to work, 43% worked fewer hours, 27% changed occupations, and 24% subsequently lost their jobs. Of these patients, 274 had lost earnings averaging $26,949 ± $22,447 (Mean ± SD), which was 60% of the pre-ARDS annual income. Survivors who never returned to work had lower health-related quality of life compared with those who returned to work.34

A meta-analysis of 52 studies in more than 10,000 patients assessed return to work after critical illness: For previously employed survivors, return to work occurred in 36% at 3 months, 60% at 12 months, and 68% at 42 to 60 months.35 No difference was found in return to work by diagnosis (ARDS or not ARDS) or by study region (North America, Europe, or Australia). After patients returned to work, job loss occurred in 20% to 36% of survivors, and 5% to 84% worked fewer hours. Other impacts were unplanned job changes, working fewer hours, and early retirement. Disability benefits were in effect in 20% to 27% of survivors at 1 year and 59% to 89% at 76 months. Potential risk factors for joblessness were longer time to return to work, preexisting comorbid disorders, and mental health impairments after critical illness.35 Intervention studies that include vocational rehabilitation are needed.

PREVENTION AND MITIGATION OF PICS

After critical illness, many survivors find themselves in a downward spiral, wherein the inability to return to work results in financial hardship, which has psychosocial ramifications.36 The impact extends to caregivers, who frequently provide care assistance for the survivor, exacerbating the financial shock felt by many.37

Despite these realizations, issues of survivorship are rarely addressed during or after the ICU stay, leaving survivors and their caregivers unprepared for the future that awaits. Survivors are resilient,6 and education, support, and empowerment are key facilitators to recovery.6,38 As described below, a key strategy to mitigate PICS is to inform survivors and their caregivers about PICS and proactively assess for PICS to identify impairments that require services, including rehabilitation.

In light of this emerging evidence supporting the prevalence and severity of PICS, efforts have been made both to prevent PICS and to treat PICS and its
sequelae after the ICU. Strategies to mitigate PICS can be considered from several different perspectives.

First, PICS prevention begins with strategies to prevent critical illness and to lessen its impact. For example, timely access to effective medical care could prevent as many as 250,000 ICU admissions annually in the United States, as ICU admissions were preceded by an ambulatory-care sensitive condition in 16% of ICU admissions.39 Separately, public awareness campaigns, like “Stop Sepsis, Save Lives,” with an emphasis on vaccinations, could prevent millions of patients over the next decade from developing PICS by preventing critical illness.40 At the end of life, through increased use of advanced care planning and palliative care, patients who express goals and preferences that do not align with high-intensity care will avoid the ICU. In addition, years of education has been associated with an increased likelihood of being PICS-free5; thus, social investment in education has additional benefits.

Second, PICS prevention is dependent on ICU care delivery that accounts for PICS risk factors and is designed to maximize the likelihood of maintaining functional independence. PICS risk factors are numerous. As detailed in Figure 1, critical illness entails intrinsic hazards, including immobilization and sedation, consequences of the catabolic, proinflammatory state, and physiological derangements (eg, hypoxemia, hypoperfusion, glucose dysregulation) and conditions (eg, delirium). The ICU Liberation Bundle41,42 is a PICS prevention bundle (Table 1).

Third, strategies to assess, prevent, and manage pain and delirium are interrelated keys to PICS prevention. Likewise, the choice of sedation is key, because certain interventions (ie, benzodiazepine infusions) are associated with delirium development. In the landmark awakening trial by Kress and colleagues,43 sedation interruption resulted in fewer midazolam equivalents (229.8 mg in the sedation interruption group vs 425.5 mg in the control group); as a result, the interruption group spent 2.4 fewer days on the ventilator and 3.5 fewer days in the ICU and were significantly more likely to be discharged home (59% vs 40%). When spontaneous awakening trials (SATs) and spontaneous breathing trials (SBTs) were implemented in a coordinated fashion, patients spent approximately 3 fewer days on the ventilator and in the ICU, experienced less coma, and were significantly more likely to be alive at 1 year.44

Fourth, early mobilization in the ICU has several short- and long-term benefits. In the short-term, patients receiving early physical and occupational therapy had shorter duration of ICU delirium by 2 days; duration of mechanical ventilation was also reduced.45 Further, return to independent functional status at hospital discharge was more frequently realized by patients in the early physical and occupational therapy arm (59% vs 35%).45

Fifth, attention must be paid to the effects of critical illness and critical care after the ICU, where early intervention in the posthospital period may mitigate some of the aspects of PICS. This is an area only beginning to be explored, and more data are needed. However, early evidence suggests that coordinated, knowledgeable implementation of multidisciplinary posthospital care for ICU survivors could result in improved outcomes, including fewer readmissions.46-50 Attempts to identify at-risk patients and target specific complications of critical illness have thus far included development of screening tests, attention to discharge planning, care coordination interventions, primary care interventions, telephone interventions, post-ICU clinics, cognitive rehabilitation, and peer support.

<table>
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<tr>
<th>Table 1. Elements of the ICU Liberation Bundle</th>
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<tr>
<td>Assessment, prevention, and management of pain</td>
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<tr>
<td>Both spontaneous awakening trials and spontaneous breathing trials</td>
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<tr>
<td>Choice of analgesia and sedation</td>
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<td>Delirium assessment, prevention, and management</td>
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<td>Early mobility and exercise</td>
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<td>Family engagement and empowerment</td>
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SCREENING AND IDENTIFICATION

Although much is known about the pre- and in-ICU risk factors predisposing to the development of PICS, there is yet no validated tool or consensus to identify patients at risk for PICS or those who may benefit from intervention. A self-report version of the Healthy Aging Brain Care Monitor has been studied as a potential clinical tool for this purpose, but it was developed for an older population and may be limited by the self-report aspect, especially the cognitive domain, which did not correlate with formal measures of cognitive function such as the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). Poor awareness of deficit is a common finding in the post-ICU population, hampering efforts to identify patients at risk by using surveys. Application of an automatically calculated readmission risk score for the purpose of identifying patients who need further attention and intervention has not been shown to be useful in ICU survivors, as such scores may fail to identify previously healthy patients for whom the critical illness represents their first serious healthcare episode. In the absence of validated clinical tools for identifying at-risk patients, clinicians engaged in post-ICU care most often use clinical criteria based on known risk factors to identify patients at risk for sequelae, including the presence of mechanical ventilation, shock, delirium, and/or length of stay.

DISCHARGE PLANNING

Attention to specialized discharge planning for survivors of critical illness is likely an underappreciated intervention that can be integrated into existing care pathways and delivered in the hospital (Table 2). In a recent randomized study implementing an ICU recovery bundle for high-risk patients, delivery of outpatient portions of the intervention was limited. The inpatient portions of the bundle consisted of an inpatient visit from an ICU nurse practitioner, an educational brochure about PICS, and medication reconciliation. Although only 12.6% of intervention patients received an outpatient intervention, a significant reduction was seen in the composite outcome of death or readmission within 30 days of hospital discharge (18% vs 29.8%; \( P = 0.04 \)) compared with patients who did not receive any components of the bundle (both groups received medication reconciliation from an ICU pharmacist), suggesting that the educational visit and brochure may have had a significant impact on outcomes. When survivors of critical illness and their families are asked about the posthospital recovery period, frustration with lack of communication and information about the recovery trajectory is among the most common themes.

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<tr>
<th>Table 2. Examples of Advice from Former ICU Patients and Families to Medical Professionals</th>
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<tr>
<td>1. Discharge orders: Patients and families need a more detailed explanation of what to expect physically, cognitively, and mentally. There needs to be more “soft talk” about potential after-effects with patients and family. Treatment plans should include protocols for how to deal with cognitive and mental challenges. Patients and families need a “cliff notes” version of the discharge papers.</td>
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<tr>
<td>2. Normalizing: Patients and families need to know that it is normal or ok to seek mental health support after ICU discharge. Doctors should make referrals.</td>
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<tr>
<td>3. Education: Families need more education about what to expect so they understand why the patient changed. This could lessen the tension and stress of the recovery process.</td>
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PERIHOSPITAL CARE COORDINATION INTERVENTIONS

Due to the high risk of complications in the post-ICU population, attempts have been made to implement care coordination or disease management interventions in the perihospital period. In a prospective study, intensive care patients who received more than 3 days of mechanical ventilation at a university medical center were randomized to usual care or 8 weeks of case management and interdisciplinary communication provided by advanced practice nurses. Most patients
were discharged to an extended care facility; only 22.8% were discharged directly to home. The investigators noted no significant difference in survival, health–related quality of life, or functional status, but survivorship cost less with the intervention than without the intervention, and readmission duration was decreased, resulting in an average savings of $19,705 per patient.

**PRIMARY CARE AWARENESS AND INTERVENTIONS**

In the United Kingdom, national guidelines recommend long-term monitoring and follow-up for survivors of critical illness. However, most countries have failed to adopt similar guidelines, and professional society recommendations are lacking at this time. In the absence of clear care pathways, the burden of post-ICU care has fallen on primary care physicians (PCPs). Although often familiar with the medical and social histories of their patients and skilled in care coordination, PCPs are given no specific training in the care of ICU survivors and the problems unique to this population. In addition, although millions of patients survive a critical illness each year, a typical PCP may only see 1 or 2 of these patients, providing PCPs with little clinical experience to allow them to identify and treat post-ICU complications. Qualitative evidence supports this idea: PCPs do not often feel confident in their abilities to recognize and treat post-ICU complications. Additional training and support for PCPs conducting post-ICU care have been suggested, but no established programs are in practice. 

Information transfer from the inpatient to the outpatient setting is a barrier to optimal care by PCPs. Furthermore, the problems of ICU survivors are vast and may require significantly more time than allotted for a typical posthospitalization visit. Although some additional reimbursement is available in the United States for complex posthospital care (transitional care codes), no specific code or care model is available for post-ICU syndrome. Thus, reimbursement is likely insufficient for the resources required to adequately care for ICU survivors in the primary care setting.

**POST-ICU CLINICS**

Chiefly described and implemented in the United Kingdom and Scandinavia, dedicated post-ICU clinics are most often team clinics dedicated to subspecialty outpatient follow-up of patients who have been critically ill. In the United Kingdom and Europe, these clinics have been nurse led. In the United States, this model of care has been growing despite financial barriers. Patients, families, and healthcare systems have perceived benefits to ICU-specific follow-up after critical illness, according to the Collaborative Assessment of ICU Recovery Needs (CAIRN) study (ClinicalTrials.gov Identifier NCT03513289). But barriers remain, not least due to a paucity of data about unmet needs after an ICU admission.

Much of the available data examine sequelae of specific ICU diagnoses, such as sepsis. Like ICU survivors in general, sepsis survivors are at high risk for posthospital complications and may benefit from targeted outpatient intervention after discharge. The risk of readmission is especially high in this group: Readmissions commonly exceed 40% in the first 3 months after hospital discharge, and 42% of these were found to be potentially preventable with timely and appropriate outpatient therapy. A recent study, delivery of recommended postsepsis care elements—medication optimization, screening for functional or mental health impairments, monitoring for common and preventable causes of health deterioration, and documentation of goals of care—was associated with reduced morbidity and mortality following a sepsis hospitalization. A prospective, comparative effectiveness analysis of Medicare data showed that the combination of early and intense home health nursing visits and early physician follow-up after a hospitalization for sepsis reduced the probability of 30-day readmission by 7 percentage points. In a retrospective comparison of resource utilization before and after an ICU stay in a US healthcare system, ICU survivors had significantly increased resource utilization in the year after critical illness, but
only 8% received new support in the form of physical therapy, occupational therapy, or cognitive or mental health treatment in the post-ICU period. In that cohort, no association was found between a non-ICU-specific outpatient visit within 2 weeks of discharge and resource utilization, suggesting that specific ICU recovery services are needed to provide the right care at the right time in order to affect posthospital outcomes for ICU survivors.

Delivery of ICU-specific follow-up care by critical care–trained clinicians in the outpatient setting, known as a post-ICU clinic, ICU follow-up clinic, or ICU recovery program, was first explored in the United Kingdom, where this model of care has gained wide acceptance and health system support. Adaptation in the US health system has been slower, perhaps in part due to lack of awareness of the problem, a paucity of data regarding effective interventions, and structural and financial barriers to designing and implementing new models of care, especially in the outpatient setting (Figure 2). Despite these challenges, several US centers have described their experiences designing, implementing, and sustaining post-ICU clinics.

As touched on above, a randomized trial of an ICU recovery bundle, which included posthospital phone and email contacts as well as a post-ICU clinic visit, showed that such an intervention was feasible, and

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**Figure 2.** Summary of key enablers and barriers to implementing ICU follow-up clinics and peer support programs

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<tr>
<th>ENABLERS TO LEVERAGE</th>
<th>BARRIERS TO PRE-EMPT</th>
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<tr>
<td>Interprofessional teamwork</td>
<td>Lack of funding</td>
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<tr>
<td>Defined operational processes</td>
<td>Lack of space</td>
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<tr>
<td>Human connection</td>
<td>Identifying appropriate patients</td>
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<tr>
<td>SCCM Thrive Collaboratives</td>
<td>Patient &amp; family attendance</td>
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<tr>
<td>Motivated clinicians</td>
<td>Creative problem-solving</td>
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although patient engagement in the outpatient portion of the intervention was low, a combined readmission and mortality outcome was decreased in the intervention group. In these pragmatic, single-center, clinical cohort studies, the prevalence of new impairments in physical function, cognition, and affect, as well as socioeconomic challenges such as inability to return to work and increased healthcare resource utilization, have mirrored or exceeded those seen in the sepsis and ARDS literature.

In an effort to accelerate new knowledge regarding the implementation of ICU survivorship programs, the Society of Critical Care Medicine fostered the Thrive Collaboratives. Some early data from these groups suggest that the potential benefits of providing ICU recovery services affect not only patients and families but also clinicians and hospital systems. As described in an international qualitative study of ICU clinicians, patients, and caregivers, post-ICU programs can drive improvement in the ICU by identifying targets for quality improvement or education, creating new roles for survivors as patient advocates and peer mentors, motivating clinicians, changing clinicians’ understanding of the patient experience, and improving morale in ICU work. Additional information regarding post-ICU clinic design and implementation is anticipated from the Thrive collaboratives. In the meantime, several studies examining alternative means of delivering outpatient interventions to this high-risk, impaired population—including telemedicine and mobile ICU recovery—are underway (ClinicalTrials.gov Identifiers NCT03926533 and NCT03053245).

PEER SUPPORT

Peer support is mutual or unidirectional support from nonprofessionals with similar stressors or health problems, which can be provided in person, by telephone, or on the internet. Peer support, used successfully outside of critical care to improve health outcomes when paired with education, could promote health among survivors of critical illness through role modeling, information sharing, and providing practical advice from those who have experienced critical illness. For example, peer support increased social connectedness, feelings of group belonging, and coping for day-to-day changes in individuals with mental illness. A systematic review of peer support for ICU survivors concluded that peer support may reduce psychological morbidity, improve social support, and improve self-efficacy among survivors of critical illness and their caregivers, yet confirmatory studies are needed. Further, although multiple models of peer support exist, including online models, it remains unclear which approach works best for survivors. One promising strategy, used in the Intensive Care Syndrome: Promoting Independence and Return to Employment (InS:PIRE) program in Glasgow, Scotland, and the Vanderbilt ICU Recovery Center in Nashville, Tennessee, is to partner peer support with ICU follow-up clinics.

The Society of Critical Care Medicine Thrive International Peer Support Collaborative gathered data on the models being used, in order to categorize differences between the models, and described facilitators and barriers of implementation of peer support. Seventeen sites from the Thrive Peer Support collaborative were included. An iterative process was used to identify key areas of peer support along with barriers and challenges to implementation. Six models of peer support were identified: peer support within the ICU, community-based models, psychologist-led outpatient models, within-ICU clinic models, peer mentor models, and online peer support. Common barriers of peer support implementation included recruitment of participants, training and input of peer support personnel, funding, risk management, and sustaining the program over time, all of which need to be addressed in implementation of a peer support program. In addition, all of the peer support models struggled with how to measure their effect on patients and family outcomes and what metrics to use to evaluate success. Although peer support models are being used, no data are available showing their effectiveness in ICU populations. However, these models have been shown to be effective in other populations. Additional research in this promising area is needed.

PSYCHOLOGICAL INTERVENTIONS

To date, few studies have focused on interventions to improve distress and psychological outcomes after critical illness. Coping is a conscious effort to control, minimize, or tolerate stressful situations, and coping
skills or strategies can be taught. Cox and colleagues\textsuperscript{71} developed and evaluated a telephone-based coping skills training intervention and showed that it reduced depression, anxiety, and PTSD symptoms in ICU survivors of acute lung injury. A randomized controlled trial that compared telephone and web-based coping skills training versus an education program found that the coping skills training intervention did not reduce depression, anxiety, or PTSD in ICU survivors at 3 or 6 months.\textsuperscript{72} However, in patients who had high levels of baseline distress, the coping skills training reduced symptoms of depression, anxiety, and PTSD and increased health-related quality of life at 6 months compared with the education program. In patients who underwent mechanical ventilation and had longer ICU stays, the education program improved distress at 3 months but not at 6 months.\textsuperscript{72} Investigations are needed to determine when coping skills training and educational programs may benefit patients.

Cognitive behavioral therapy is often recommended as a first-line treatment for PTSD symptoms in other populations. In non-ICU populations, exposure therapy or a combination of exposure with cognitive behavioral therapy has been shown to be effective.\textsuperscript{73} Cognitive behavioral therapy is also widely used to treat depression and anxiety. A study in ICU survivors used a brief cognitive behavioral psychoeducation program to manage stress and anxiety in family caregivers of ICU patients; the group receiving the intervention was compared with a no-intervention group.\textsuperscript{74} The cognitive behavioral psychoeducation intervention reduced stress, anxiety, and depression and increased satisfaction in family caregivers. Cognitive behavioral therapy is a promising treatment for survivors of critical illness, but no studies have been conducted to date.

**COGNITIVE REHABILITATION**

Intervention to improve cognitive impairment is an important and growing area of research. One way to improve cognitive outcome is by focusing on factors associated with cognitive impairments. A review of 28 studies assessing potentially modifiable risk factors for cognitive impairments after critical illness found that delirium, glucose dysregulation (hypoglycemia or hyperglycemia), and hypoxia were potentially modifiable risk factors in the development of cognitive deficits after critical illness.\textsuperscript{75} A systematic review and meta-analysis of 6 randomized controlled trials found that early rehabilitation improved short-term physical-related outcomes and decreased ICU-acquired weakness but did not improve cognitive function (measured as cognitive-related delirium-free days) compared with standard care or no early rehabilitation.\textsuperscript{76}

Another way to improve cognitive function is by using cognitive rehabilitation; this entails interventions targeted at improving cognitive impairments that arise after critical illness due to brain damage. Cognitive rehabilitation has several approaches, including use of strategies or compensatory mechanisms to minimize weaknesses or maximize strengths and use of computerized cognitive rehabilitation via brain-training computer programs (like conventional video games) to improve or restore cognitive function. A study in 34 ICU survivors who underwent 6 weeks of cognitive rehabilitation in combination with combined strength training and walking found a significant improvement in cognitive function compared with controls.\textsuperscript{77} A study of 21 general medical ICU survivors used a program of cognitive, physical, and functional rehabilitation for 12 weeks.\textsuperscript{78} At baseline there was no difference in cognitive function between the 2 groups. At the 3-month follow-up, the intervention group showed significant improvement in executive function and IADLs compared with the control group.\textsuperscript{78} Both studies used a combined cognitive and physical intervention, so it is unclear whether physical rehabilitation, cognitive rehabilitation, or both contributed to improved cognitive function.

Using a complex multifaceted intervention, Zhao et al\textsuperscript{79} randomized ICU survivors to a twice-weekly, 12-week intervention consisting of learning to play an electronic musical keyboard (30 minutes); learning simple Spanish (30 minutes); memorizing a clock, including time, shape, style, and background (10 minutes and then reproduce the clock); and talking to a psychiatrist for 30 minutes. No difference was noted in baseline cognitive function between the 2 groups. At 3-month follow-up, cognitive impairment occurred in 59% of the intervention group and 82% of the control group. Younger patients had better cognitive outcomes compared with older patients.\textsuperscript{79} Taken together, the 3 studies described above provide support for the use of cognitive rehabilitation in ICU survivors.
Computerized cognitive rehabilitation has also been used to improve cognitive outcome in ICU survivors. A pilot study used computerized cognitive exercises in 20 patients admitted to the ICU. The patients received a daily 20-minute session of computerized cognitive exercises, which increased in difficulty as the training progressed. Patients were able to complete 87% of the possible cognitive exercise sessions and reported that they enjoyed the sessions and found them relaxing; the cognitive training did not cause undue fatigue. No cognitive exercise session was stopped for patient safety, and no adverse events were reported.

A second computerized cognitive rehabilitation pilot study consisted of adaptive exercises to optimize speed and memory. Thirty-three ICU survivors completed 7 cognitive exercises daily, 5 days a week for 12 weeks. Baseline computerized cognitive rehabilitation scores were compared with the post-intervention scores and showed significant improvement over time. The amount of improvement in cognitive function was positively correlated with the number of hours of cognitive rehabilitation training. No differences were found in pre- compared with postintervention neuropsychological test scores, and the study was likely underpowered to detect such a difference. These data suggest that computerized cognitive rehabilitation interventions may be a promising way to improve cognitive outcomes after critical illness. Importantly, computerized cognitive interventions require less face-to-face interaction with clinical professionals compared with standard cognitive rehabilitation methods. Additional research is needed to determine whether computerized cognitive rehabilitation improves cognitive function in survivors of critical illness.

SUMMARY

Posthospital care of ICU survivors remains both a challenge and an opportunity. The mandate to optimize critical illness recovery with tailored survivorship programs seems clear. Additional research and clinical experience are needed to further delineate the needs of ICU survivors and develop effective interventions to mitigate the effects of PICS, with the goal of maximizing recovery after critical illness.

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