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AHA SCIENTIFIC STATEMENT

Prevention of Complications in the Cardiac Intensive Care Unit

A Scientific Statement From the American Heart Association

ABSTRACT: Contemporary cardiac intensive care units (CICUs) have an increasing prevalence of noncardiovascular comorbidities and multisystem organ dysfunction. However, little guidance exists to support the development of best-practice principles specific to the CICU. This scientific statement evaluates strategies to avoid the potentially preventable complications encountered within contemporary CICUs, focusing on those that are most applicable to the CICU environment. This scientific statement reviews evidence-based practices derived in non–CICU populations, assesses their relevance to CICU practice, and highlights key knowledge gaps warranting further investigation to attenuate patient risk.

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Key Words: AHA Scientific Statements ■ cardiovascular drugs ■ critical care ■ cross infection ■ delirium ■ prevention ■ respiration, artificial ■ shock, cardiogenic

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Critically ill patients are inherently susceptible to a multitude of complications related to both the severity of underlying illness and the need for intensive care therapies.[1,2] Many of these complications are associated with increased morbidity and mortality and often result in greater resource use and healthcare expenses and longer intensive care unit (ICU) lengths of stay.[1–3] A number of these complications are potentially preventable, and their incidence rates are used as quality metrics within modern-day ICU settings.[4] Contemporary cardiac ICUs (CICUs) have an increasing prevalence of noncardiovascular comorbidities and multisystem organ dysfunction.[5,6] Thus, it stands to reason that patients admitted to contemporary CICUs will be susceptible to similar preventable complications associated with both their multisystem critical illness and the resources required to treat their complex conditions. At the same time, there is a need among CICU providers to understand those complications that are most applicable to critically ill cardiovascular patients, who may not be well represented in the general ICU. As a result, there may be opportunities to improve CICU outcomes through the implementation of evidence-based preventive practices. However, little guidance exists to support the development of best-practice principles specific to the CICU environment.[7]

This scientific statement focuses on the potentially preventable complications encountered within contemporary CICUs. Although many of these complications are shared with other medical and surgical ICU settings, some are unique to the CICU environment. We review evidence-based practices derived in relevant critical care populations, assess their relevance to CICU practice, and highlight key knowledge gaps warranting further investigation to attenuate patient risk.

PREVENTION OF CICU-ACQUIRED INFECTIONS

Infections and sepsis are prevalent in CICU populations, both on admission and as acquired complications during hospitalization.[8,9] Patients in the CICU

increasingly receive therapies such as invasive medical devices for hemodynamic monitoring, short-term mechanical support, renal replacement therapy, and targeted temperature management (TTM), which are associated with increased risk for health care–associated infections (HAIs).[6] HAIs include catheter-associated urinary tract infection (CAUTI), central line–associated bloodstream infection (CLABSI), ventilator-associated pneumonia (VAP), infection with multidrug resistant (MDR) pathogens, and surgical site infections occurring with mechanical circulatory support (MCS). Although there are no CICU-specific guidelines available to inform best practice HAI prevention, guidance on the prevention of HAIs is reviewed herein with a focus on CICU populations.[10–19]

Hand hygiene is critically important, and improved compliance reduces the incidence of HAIs.[15] Hands should be washed with either alcohol-based hand sanitizer or soap and water before and after any patient contact. Alcohol-based hand sanitizer is effective for preventing the spread of most MDR pathogens; soap and water may be more effective for preventing the spread of diarrheal pathogens, including *Clostridium difficile*.[15,18]

Prevention of Percutaneous MCS Device–Related Infections

In contemporary CICUs, the use of temporary MCS devices is common, ranging from 7% to 10% of admitted patients.[6,20] The rates of infection vary with duration of use and type of MCS device, with reported incidences ranging from 1% for intra-aortic balloon pumps and Impella[21] to nearly one-third of patients requiring extracorporeal membrane oxygenation (ECMO) support.[22] The duration of MCS has consistently been shown to be a major risk factor for the development of infections[23] and is particularly relevant for contemporary CICUs because the duration of ECMO support has increased over time.[24] A multicenter study of patients receiving ECMO found that infection rates increased from 6% for patients requiring ECMO support for ≤1 week to 29% in patients on ECMO for >2 weeks.[25] Although not the focus of the present document, infection remains one of the most frequent complications of durable MCS devices, including both localized device and driveline infections and pump-associated bloodstream infections.[26] Peri-implantation antibiotic prophylaxis may be appropriate for selected patients with temporary MCS devices who are at elevated risk of infection (ie, patients with a longer anticipated duration of temporary MCS), as is standard for durable MCS device implantation.[27] In addition, it is reasonable to use temporary MCS support for the minimum duration necessary to mitigate the risk of associated infections. Alternative vascular access sites for temporary MCS (ie, axillary artery) have been reported and could reduce infection rates, but data to support this strategy are limited.

Prevention of CLABSI

CLABSI is defined by the Centers for Disease Control and Prevention (most updated protocol: https://www.cdc.gov/nhsn/pdfs/pscmanual/4psc_clabscurrent.pdf) as a laboratory-confirmed bloodstream infection with either a recognized bacterial or fungal pathogen cultured from ≥1 blood cultures and unrelated to infection at another site or a common commensal organism (eg, coagulase-negative Staphylococcus) in ≥2 blood cultures collected on different days/different sites unrelated to infection at another site and associated with ≥1of the following signs or symptoms: fever (>38.0°C), chills, or hypotension. For surveillance purposes, CLABSI refers to a primary bloodstream infection meeting the above criteria for >2 consecutive calendar days.

The incidence of CLABSI in contemporary CICUs has not been well described, although among patients hospitalized in ICUs the United States, CLABSI incidence decreased from 3.64 to 1.65 infections per 1000 central-line days between 2001 and 2009.[28,29] CLABSI is associated with higher hospital costs, longer length of stay, and potentially greater mortality.[12] Risk factors for CLABSI include both host factors (eg, chronic illness, immunodeficiency, malnutrition, and age)[30,31] and catheter factors (eg, duration of catheterization, type of catheter, conditions of insertion, access site care, and skill of catheter inserter).

Prevention of CLABSI is multifactorial, but limiting the use of intravascular catheters and the number of intravascular catheter days is the most important strategy to prevent CLABSI.[12] Although routine replacement of central venous catheters (CVCs) is not recommended,[32] regular evaluation for CVC necessity and surveillance for access site infections is good practice. The risk of CLABSI is lowest with subclavian vein followed by internal jugular vein CVC placement.[12,33] Use of antimicrobial-impregnated catheters or dressings is reasonable if catheter-related infections have not fallen to acceptable levels (which may include zero infections) despite implementation of other preventive measures.[34] Appropriate use of tunneled catheters or peripherally inserted central catheters may reduce the risk of infection when long-term central venous access is required for longer-term medication administration. However, the benefits and risks must be balanced.[12] In particular, to prevent damage to central and peripheral arteries and veins, caution is advised with the use of peripherally inserted central catheters for patients on dialysis or with chronic kidney disease (glomerular filtration rate <60 $mL \cdot min^{-1} \cdot 1.73\ m^{-2}$) when dialysis access is expected in the future.[35,36] When the use of intravascular catheters, including CVCs, arterial lines, or percutaneous MCS devices, is necessary, a multicomponent central-line bundle should be implemented to reduce the risk of CLABSI (Table 1), including the 5 evidence-based strategies defined by the Centers for Disease Control and Prevention[37]:

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Table 1. Strategies for Prevention of CLABSI

Prior to CVC insertion	During CVC insertion	After CVC insertion
Use CVC only when necessary for established indications	Checklist to ensure compliance with CVC bundle	Remove CVC as soon as no longer indicated
Consider alternatives to CVCs when indicated	Perform hand hygiene before and after CVC insertion	Disinfect hubs and injection ports before accessing CVC
Bathe daily with 2% chlorhexidine	Clean skin using alcoholic >0.5% chlorhexidine solution and let dry	Use antiseptic-containing hub/connector caps
Consider appropriate CVC site	Use aseptic technique and sterile equipment for catheter insertion	Change dressing and perform site care with chlorhexidine every 5-7 days or if dressing is compromised
Avoid routine use of guidewire exchanges, especially if infected	Avoid femoral vein site for routine CVC placement	Use antimicrobial ointments for dialysis catheter insertion sites
Ensure proper education regarding CLABSI prevention among providers placing CVCs	Use ultrasound guidance for cannulation when indicated	Perform hand hygiene before and after CVC manipulation
	Use smallest CVC with minimum number of lumens necessary	Properly secure CVC to avoid skin trauma (sutureless device)
	Consider antimicrobial-coated CVCs if infection rates remain high	Do not routinely replace CVC
	Use chlorhexidine-containing dressings	Consider antimicrobial locks for patients with prior CLABSI
	Avoid systemic antibiotic prophylaxis	Use lower nurse-to-patient ratios
		Do not submerge CVC in water; showering only if protected by impermeable barrier

CLABSI indicates central line-associated blood stream infection; and CVC, central venous catheter.
Data derived from Yokoe et al[10] and O'Grady et al.[12]

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1. Washing hands with soap and water before placement or manipulation
2. Ensuring staff are adequately trained in sterile insertion using full barrier precautions (cap, mask, sterile gown, sterile gloves, and full sterile drape)
3. Using 2% chlorhexidine solution with proper air drying before insertion
4. Avoiding femoral site for catheterization
5. Promptly removing unnecessary catheters

Furthermore, a quality improvement approach to CLABSI prevention is recommended, including collecting and monitoring data of CLABSI rates and evaluating each CLABSI for preventable contributing factors.

Prevention of VAP

VAP is defined as pneumonia occurring in patients who are endotracheally intubated and mechanically ventilated for >48 hours.[13] Recent data have demonstrated that up to 1 in 5 patients in contemporary CICUs require mechanical ventilation (MV) during hospitalization, with rates increasing over time.[5,6] One single-center CICU study from 2002 to 2003 noted an incidence of VAP of 36.3% per 1000 days of MV.[38] Patients who are mechanically ventilated after cardiac arrest, particularly those receiving therapeutic hypothermia, are at a higher risk of developing VAP, likely because of the high prevalence of intra-arrest aspiration.[39,40] A recent randomized controlled trial demonstrated a significantly lower rate of VAP (19% versus 34%) with 2 days of prophylactic amoxicillin/clavulanate versus placebo after cardiac arrest without a difference in the rate of adverse events, duration of MV, or mortality.[41] Finally, noninvasive ventilation modalities can be considered in appropriately selected patients to reduce the duration of endotracheal intubation through either avoidance of initial intubation or facilitation of early extubation.[13] Several interventions reduce the risk of VAP in patients with MV (Table 2).

Prevention of CAUTI

CAUTIs are a common occurrence in hospitalized patients, with an estimated 1.4 to 1.7 per 1000 catheter days in general ICUs,[42] although data among patients admitted to CICUs are unavailable. The most important risk factor for developing CAUTI is duration of catheterization,[14] with other risk factors including female sex, older age, diabetes mellitus, bacterial colonization of the drainage bag, and errors in catheter care.[43]

Limiting the overall use of urinary catheters and the number of urinary catheter days is the most important strategy for preventing CAUTI.[11,14] Table 3 outlines measures to reduce the risk of CAUTI among those patients with an ongoing indication for a urinary catheter.

Prevention of Other HAIs

MDR pathogens, including methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant Enterococcus, *C*

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Table 2. Strategies to Reduce the Incidence of VAP

Best practices	
Benefits likely outweigh risks	Use of NI-PPV in selected populations
	Have sedation protocols with targeted light sedation
	Interrupt sedation daily if appropriate
	Assess readiness to extubate daily
	Perform SBT off sedation
	Early mobilization
	Place ETT with subglottic suction (if >48–72 h IMV)
	Change MV only when soiled
	Position head of bed >30°
Special approaches	
Proven efficacy but uncertain risks	Selective oral or digestive decontamination
Uncertain effects on clinical outcomes	Regular oral care with chlorhexidine
	Prophylactic probiotics in selected patients
	Ultrathin polyurethane ETT cuffs
	Automated control of ETT pressure
	Saline instillation during endotracheal suctioning
	Mechanical toothbrushing
Generally not recommended	
Does not lower VAP rates or improve outcomes	Silver-coated ETTs
	Kinetic beds
	Prone positioning
	Stress ulcer prophylaxis
	Early tracheostomy
	Monitoring gastric residual volumes
	Early parenteral nutrition
	Closed/in-line endotracheal suctioning

ETT indicates endotracheal tube; IMV, intermittent mandatory ventilation; MV, mechanical ventilation; NI-PPV, noninvasive positive pressure ventilation; SBT, spontaneous breathing test; and VAP, ventilator-associated pneumonia.

Data derived from Yokoe et al.[10] Adapted from Klompas et al[13] with permission.

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difficile, and MDR Gram-negative rods, are increasingly common among hospitalized patients.[10,15,44] Although few specific data exist, patients in the CICU are considered at risk of colonization and infection by MDR pathogens because of healthcare exposure and the frequent use of antibiotics, CVCs, and MV.

Use of gown-and-glove contact precaution strategies has not been consistently effective for preventing the transmission of MDR pathogens in clinical trials, potentially because of inadequate rates of provider compliance or low prevalence of MDR pathogens outside of outbreak conditions.[10,15] Nonetheless, this strategy is reasonable given its simplicity and limited risk. Recommended practices to prevent the spread of MDR pathogens[10,15] include the following:

1. Meticulous hand hygiene, preferably with alcohol-based hand sanitizer
2. Proper cleaning and disinfection of equipment and environment
3. Gown-and-glove contact precautions for patients colonized and infected with MDR pathogens
4. Implementation of an institutional monitoring system for patients colonized or infected with MDR pathogens

If outbreaks of MDR pathogens occur, diligent compliance with the aforementioned best-practice principles should be reinforced.[10,15] The effectiveness of routine daily bathing with chlorhexidine for reducing rates of CLABSI, methicillin-resistant *S aureus* infection, and acquisition of MDR pathogens may depend on the baseline population risk, and this strategy is more likely to be of benefit when infection rates are high in a given CICU.[10,45] Nasal application of mupirocin ointment appears to reduce the risk of *S aureus* (including methicillin-resistant *S aureus*) infection in patients in the ICU and may reduce the risk of surgical site infection in patients undergoing cardiac surgery or implantation of a cardiac device (including durable MCS).[10] A recent meta-analysis that included some patients in the CICU found a 59% reduction in methicillin-resistant *S aureu* infections with mupirocin use in nonsurgical units.[46]

C difficile infection (CDI) is one of the leading HAIs.[10,18,19] Hand hygiene is essential to prevent the transmission of CDI, and soap and water may be preferred over alcohol-based hand sanitizer.[10,18] The use of gown-and-glove contact isolation precautions for patients with confirmed or suspected CDI (including patients with hospital-acquired diarrhea before excluding CDI) and the use of dedicated patient care equipment and cleansers active against *C difficile* spores for room may prevent their spread.[10,18] Use of narrow-spectrum antibiotics when appropriate may reduce the risk of CDI as part of an institutional antibiotic stewardship program.[18]

Antibiotic Stewardship and Prevention of Antibiotic Resistance

Antibiotic stewardship has been defined as coordinated interventions designed to improve and measure the appropriate use of antibiotic agents, including choice of agent, duration of therapy, dosage, and route of administration.[47] Potential benefits associated with an antibiotic stewardship program include increased microbial susceptibility rates to targeted antibiotics (ie, reduced prevalence of MDR organisms) and improved patient outcomes, including a reduction in CDI.[47] Despite a dearth of studies examining the outcomes associated with stewardship programs in the CICU setting, implementation of antibiotic stewardship programs in all critical care units has been advocated.[48]

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Table 3. Strategies for Prevention of Catheter-Associated Bacteriuria and CAUTI

Before Urinary Catheter Insertion	During Urinary Catheter Insertion	After Urinary Catheter Insertion
Use urinary catheters only when necessary for established indications	Use only trained, dedicated personnel to insert catheters	Remove urinary catheters as soon as no longer indicated
Avoid routine use of urinary catheters for management of incontinence	Perform hand hygiene before and after urinary catheter insertion	Maintain drainage bag and connecting tubing below the level of the bladder
Use portable bladder scanners to assess need for catheterization	Clean urethral meatus with antiseptic solution	Maintain unobstructed urine flow in collecting system
Consider condom catheterization for men without urinary retention	Use aseptic technique and sterile equipment for catheter insertion	Avoid routine catheter irrigation or daily meatal cleansing
Consider intermittent catheterization	Consider use of a preconnected catheter and tubing system	Perform hand hygiene before and after catheter manipulation
	Consider use of antimicrobial-coated urinary catheters	Properly secure catheters to avoid meatal trauma
	Avoid systemic antibiotic prophylaxis	Replace catheter and collecting system only for breaks in aseptic technique, disconnection, or leakage

CAUTI indicates catheter-associated urinary tract infection.
Data derived from Hooton et al[11] and Lo et al.[14]

Suggestions for CICU Practice

- We suggest that all CICUs monitor for the presence of preventable HAI and MDR pathogens and use preventive strategies, including meticulous hand hygiene.
- We suggest minimizing the duration of invasive medical appliances.
- We suggest that all CICUs use best-practice care bundles to prevent common HAIs, including CLABSI, CAUTI, and VAP (Tables 1–3).

APPROACH TO ANALGESIA AND SEDATION AND THE DIAGNOSIS AND PREVENTION OF DELIRIUM

General Approach: ABCDEF Bundle

As described, respiratory insufficiency is the leading indication for CICU admission, with >25% of admitted patients requiring MV.[5] Endotracheal intubation presents a barrier to communication, and patients frequently require intravenous analgesia and sedation, which may alter or impair mental status. As a result of the recognition that up to two-thirds of patients experience pain or agitation in ICUs, together with a temporal increase in MV in contemporary CICUs, there is a growing need for CICUs to adopt a structured, evidence-based approach to the evaluation of patients with physical or cognitive barriers to communication.[49,50] The adoption of best practices for pain, anxiety, agitation, and delirium management in this high-risk cardiovascular population has the potential to minimize missed diagnoses and to reduce excessive sedation and its ancillary complications. Notably, the concurrent application of these strategies as an ABCDEF bundle (assessment and management of pain; spontaneous awakening and breathing trials; analgesia and sedation choice; delirium monitoring, prevention, and treatment; early mobilization and exercise; family engagement and empowerment) has been reported to reduce delirium, MV duration, mortality, and readmission in patients in the general ICU.[51] The components of this bundle are discussed below, and our suggested approach tailored for the CICU environment is provided in Figure 1.

Pain and Analgesia

Acute pain and chronic pain are common in the general ICU; however, data in the CICU have not been well described.[49] The clinical rationale for unit-based protocols for the timely identification and treatment of pain among critically ill patients is highlighted by the association between postdischarge memory of pain and the development of posttraumatic stress disorder and by the role of pain in the pathogenesis of ICU delirium.[52] We concur with the recommendations for pain assessment tools in adult critically ill patients published by the Society of Critical Care Medicine.[53] Assessment of self-reported pain is standard of care in patients who are able to verbally communicate, but validated tools are required in patients with verbal (eg, endotracheal tube) or cognitive (eg, delirium or sedation) barriers to communication (Figure 1). In patients who can communicate nonverbally, the 0 to 10 Numeric Rating Scale Visual has the highest response rate. Among patients who cannot self-report pain, behavioral assessment tools such as the Critical-Care Pain Observation Tool, the Behavioral Pain Scale for intubated patients, and the Behavioral Pain Scale–Nonintubated are the most reliable.[53]

Pain assessment should be an initial diagnostic step because pain can be a direct cause of agitation or

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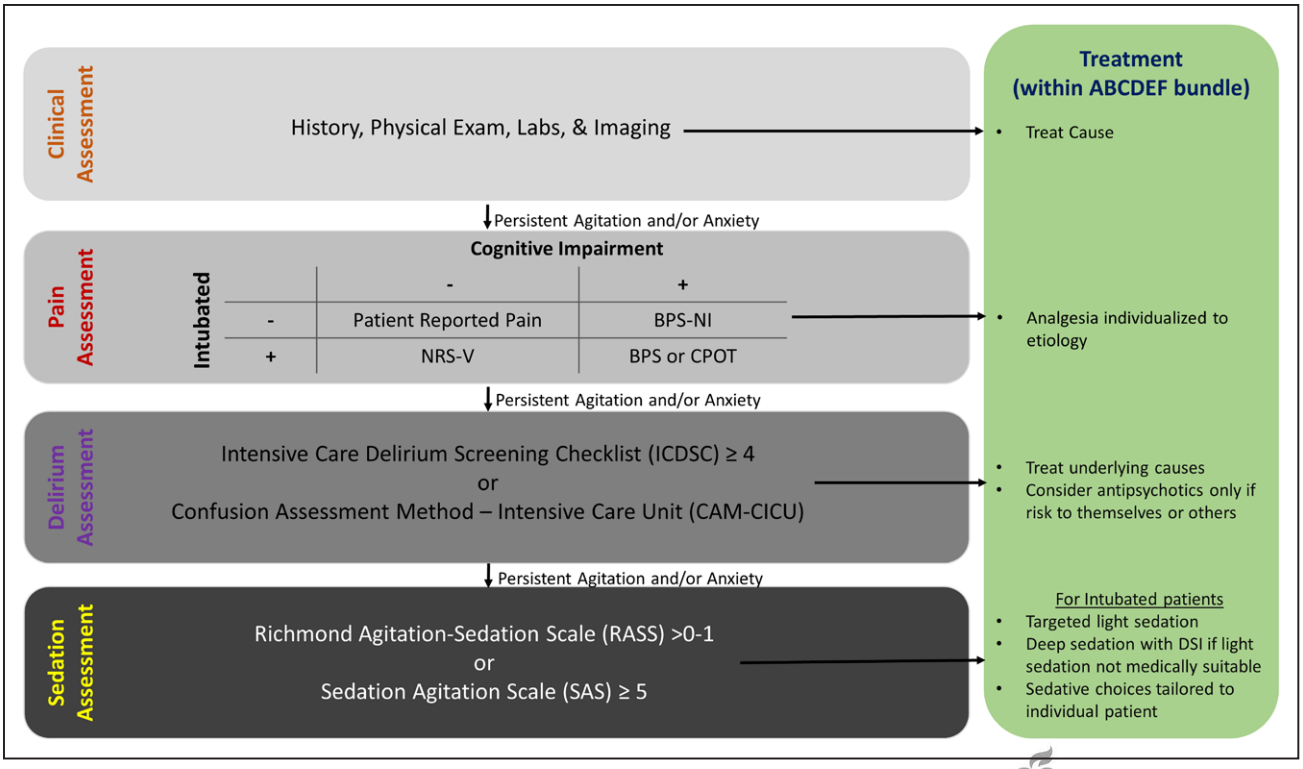

Figure 1. Approach to the assessment of agitation, anxiety, or delirium in the coronary intensive care unit.
ABCDEF indicates assessment and management of pain; spontaneous awakening and breathing trials; analgesia and sedation choice; delirium monitoring, prevention, and treatment; early mobilization and exercise; family engagement and empowerment; BPS, Behavioral Pain Scale; BPS-NI, Behavioral Pain Scale–Nonintubated; CPOT, Critical-Care Pain Observation Tool; DSI, daily sedation interruption; and NRS-V, Numeric Rating Scale Visual.

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delirium, and its treatment may mitigate the need for further sedation. At the same time, it is important to also balance adequate analgesia with oversedation, a practice associated with failed spontaneous breathing trials (SBTs), coma, and delirium.[54] In the ICU literature, randomized studies with analgesia-based sedation compared with benzodiazepine-based regimens showed reduced MV time and ICU length of stay.[53,55] It should be noted, however, that these studies did not formally test a stepped analgesia-sedation assessment strategy, and differential pharmacokinetics between the treatments also may explain some of the findings. Furthermore, these studies included only a small proportion of nonsurgical patients with cardiovascular conditions.

Standard analgesics and sedatives and their common side effects are presented in Table 4. Given the heterogeneous pain syndromes encountered in the CICU, we suggest that pain treatment be individualized to the underlying cause, primary cardiovascular condition, and comorbidities. Standard analgesics may be appropriate for many patients, but the optimal first-line therapies should be tailored to the underlying disease state (eg, nitroglycerin for ischemic pain, colchicine for pericarditis, or furosemide for hepatic capsular distension in acute heart failure). In addition, it is reasonable to consider the selective use of adjuvant nonpharmacological techniques, including music, massage, heat, or ice, despite low levels of supporting evidence, given the low risk of adverse clinical events in most patients.

Suggestion for CICU Practice

- We suggest that all CICUs routinely assess pain with validated instruments, including the Numeric Rating Scale, Critical-Care Pain Observation Tool, or Behavioral Pain Scale (as appropriate), in patients with verbal or cognitive barriers to communication. Pain should be treated before the administration of sedative-hypnotics, and treatment regimens should be individualized to the underlying cause and patient comorbidities.

Delirium

Delirium is an acute and often fluctuating disorder characterized by changes in perception, cognition, and attention that may present with hyperactive, hypoactive, or mixed phenotypes. In CICU cohorts, the reported incidence is 8% to 20% and has been associated with an increased risk for prolonged length of stay, discharge to a skilled nursing facility or long-term care, and in-hospital mortality.[56,57] In the ICU literature, delirium has also been associated with prolonged MV, increased hospital cost, and long-term cognitive impairment.[58] Nursing-led delirium screening with either the Intensive Care

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Table 4. Overview of Common Analgesic and Sedative-Hypnotic Agent Use in the CICU Population

Drug	Selected Pharmacokinetic Properties			Potential CICU Patient Populations		Serious or Common Side Effects	
	Analgesia	Sedation/ Amnesia	Other	Indications	Contraindications	Cardiovascular	Noncardiovascular
Analgesics							
Opioids	Yes	Yes	Antishivering	Acute heart failure Analgesic-based sedation Respiratory distress TTM Cardiogenic shock Hemodynamic instability Opioid dependence Ischemic pain	Renal failure or RV dysfunction (morphine) Renal failure (morphine)	Hypotension	Respiratory depression Histamine release/ pruritis (morphine) Ileus and gastroparesis Reduced absorption of ADP inhibitors Muscle rigidity (fentanyl) Bioaccumulation (fentanyl in hepatic failure)
NSAIDs	Yes	No	Antipyretic Anti-inflammatory	Pericarditis CPR pain	Heart failure Renal dysfunction Coronary artery disease (except ASA) Antiplatelet/ anticoagulants ACE inhibitor/ARBs Active bleeding or diathesis	Acute heart failure	Risk of bleeding (especially gastrointestinal) Acute kidney injury
Acetaminophen	Yes	No	Antipyretic	CPR pain Postprocedural pain Opioid-sparing agent	Liver dysfunction	None	Liver toxicity at supratherapeutic doses
Sedative-hypnotics							
Propofol	No	Yes	Antiseizure Antishivering	Short-term sedation (Post)procedural sedation TTM VT storm Elevated ICP Postarrest seizure/ myoclonus	Cardiogenic shock	Hypotension Negative inotropy Venodilation/ vasodilation	Propofol infusion syndrome Pancreatitis Hypertriglyceridemia
Dexmedetomidine	No	Yes	Antishivering	(Post)procedural sedation TTM Agitated delirium	Bradycardia (or risk of) RV infarction Cardiogenic shock	Hypotension (less than propofol) Negative inotropy/ chronotropy	Bradycardia
Ketamine	Yes (adjunct agent)	Yes	Antishivering	Short-term sedation (Post)procedural sedation TTM	Increased ICP	Hypotension; caution with catecholamine depletion Hypertension Bradycardia	Hallucinations/ dissociation (use with benzodiazepine)
Benzodiazepines	No	Yes	Anxiolytic	EtOH withdrawal Toxidrome treatment Postarrest seizure/ myoclonus	Elderly High-risk delirium CYP3A4 drugs (midazolam) Renal dysfunction (midazolam)	Hypotension	Delirium Propylene glycol acidosis (lorazepam, diazepam)

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Table 4. Continued

Drug	Selected Pharmacokinetic Properties			Potential CICU Patient Populations		Serious or Common Side Effects	
	Analgesia	Sedation/ Amnesia	Other	Indications	Contraindications	Cardiovascular	Noncardiovascular
Other							
Antipsychotics	No	At higher doses	Antipsychosis	Agitated delirium Psychiatric indications	Long QTc	Hypotension Long QT (aripiprazole safer)	NMS Extrapyramidal symptoms

ACE indicates angiotensin-converting enzyme; ARB, angiotensin receptor blocker; ASA, acetylsalicylic acid; CICU, coronary intensive care unit; CPR, cardiopulmonary resuscitation; EtOH, ethyl alcohol; ICP, intracranial pressure; NMS, neuroleptic malignant syndrome; NSAID, nonsteroidal anti-inflammatory drug; RV, right ventricular; TTM, targeted temperature management; and VT, ventricular tachycardia.

Delirium Screening Checklist or Confusion Assessment Method–Intensive Care Unit have demonstrated the best sensitivity, specificity, and interobserver reliability.[59] Although the early identification of delirium can potentially lead to the identification of modifiable risk factors and treatable causes, the association between routine screening and improved outcomes remains uncertain. Multifaceted unit-level programs may reduce the risk of delirium (Figure 1).[53] Routine antipsychotic use in critically ill patients with delirium does not shorten delirium duration or improve survival; however, sedative agents may be required in the subset of patients with hyperactive delirium who pose a risk of harm to themselves or others.[60] Most antipsychotic drugs can prolong the QTc interval, and the QTc should be monitored accordingly; minimizing QTc-prolonging antipsychotic agents in the CICU is reasonable given the susceptibility of ventricular arrhythmias in certain populations (see the Antiarrhythmic Therapy section).

Suggestions for CICU Practice

- We suggest that patients in the CICU undergo routine screening for delirium with either the Intensive Care Delirium Screening Checklist or the Confusion Assessment Method–Intensive Care Unit. Minimizing the use of medications associated with delirium, including benzodiazepines, and implementing early mobilization protocols may reduce the risk of delirium.
- The use of antipsychotics in the CICU should be restricted to patients with hyperactive delirium who are at risk of harming themselves or others and have a low risk for long QTc–associated arrhythmias.

Anxiety and Agitation

In critically ill patients receiving MV, the requirement for sedative-hypnotic agents is common despite appropriate analgesia and delirium treatment.[50,53,61] The administration of some continuous intravenous sedatives, without a standardized sedation protocol and targets, has potential to lead to excess drug accumulation. Drug-drug interactions, the duration of MV, an aging CICU population, a growing prevalence of acute and chronic renal dysfunction, acute liver injury, or excessive fluid accumulation can further alter the pharmacokinetics of common sedative-hypnotics and contribute to delayed emergence.[8,61,62]

Implementation of nursing-led sedation protocols targeting light sedation with either the Richmond Agitation-Sedation Scale or Sedation Agitation Scale is an evidence-based approach to minimize the risk of excess sedation in patients with MV. Light sedation aims to keep the patient rousable, comfortable, and able to follow commands; Richmond Agitation-Sedation Scale targets of –2 to 1 and –1 to 0 have been proposed for the ICU and CICU, respectively.[2,53,61] Meta-analyses of randomized controlled trials have reported that light sedation protocols have resulted in shorter MV time and fewer tracheostomies.[53] In the CICU, the prospective implementation of a structured nursing-led sedation protocol that included a Richmond Agitation-Sedation Scale target of 0 to –1 reduced mean ventilation times by 1.1 days.[61] When light sedation targets are medically inappropriate, daily sedation interruption (DSI), wherein sedatives are discontinued until the patient is awake and able to open his or her eyes and follow commands, is an alternative clinical approach designed to facilitate sedative drug clearance, neurological examination, suitability for light sedation, and readiness for extubation. Of note, the addition of routine DSI to structured light sedation does not improve clinical outcomes, but it may be an alternative in patients who require deeper sedation goals.[53,63,64]

Sedative Agent Selection

No single agent is suitable or safe for all patients in the CICU. Thus, selecting a sedative in the CICU requires an understanding of the effect of each agent on cardiovascular hemodynamics, along with its pharmacokinetics, pharmacodynamics, and potential side effects. In the general critical care population, routine early use of dexmedetomidine did not shorten the duration of MV or ICU length of stay or reduce the risk of delirium compared with usual care and was associated with a higher risk of bradycardia and hypotension.[65] However, it may be reasonable to use dexmedetomidine as a bridge to

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lighter sedation among select populations, including in preparation for extubation. An overview of sedative-hypnotics, their complications, and common CICU patient populations in whom these agents may be used or avoided is provided in Table 4.

Suggestions for CICU Practice

- We suggest that patients in the CICU requiring MV who remain anxious or agitated after appropriate pain or delirium treatment be treated with a sedation protocol that targets light sedation (eg, Richmond Agitation-Sedation Scale score of −1 to 0). DSI can be considered in patients requiring deep sedation to facilitate neurological assessments or the suitability for light sedation.
- We suggest tailoring the sedative agent selection to the individual patient's presenting condition, comorbidities, hemodynamics, and perceived duration of MV. It is reasonable to avoid intravenous benzodiazepines as a routine first-line sedative-hypnotic given the risk of delirium (Table 4) in the absence of clear medical indications.

Ventilatory Dyssynchrony and Shivering: Neuromuscular Blocker Use

In ventilated patients treated in general medical or surgical ICUs, use of neuromuscular blockers (NMBs) can help improve oxygenation or ventilation in selected patient populations (eg, those with acute respiratory distress syndrome [ARDS] or status asthmaticus).[66] Their use in the CICU population is likely more limited, with the most common indications being severe ventilator dyssynchrony refractory to sedation alone, severe refractory hypoxemia, and refractory shivering in patients receiving TTM. Use of NMBs should be tempered by the growing recognition of an association between NMBs and postdischarge ICU-acquired weakness (ie, myoneuropathy).[66,67] In addition, NMB use in the TTM population may increase the risk of unrecognized seizure activity, leading some societies to advocate for a stepwise approach to shivering management (skin counterwarming measures, intravenous magnesium, opioids, and sedative-hypnotics agents) that can reduce the need for NMBs to <5%.[68–70]

Suggestion for CICU Practice

- Although a detailed review of NMB indications, contraindications, pharmacokinetics, and monitoring is beyond the scope of this scientific statement, we concur with guidelines published by other organizations.[66] In the mechanically ventilated CICU population, we suggest that NMB use be restricted to patients with refractory hypoxemia, hypercarbia, dyssynchrony, or TTM-associated shivering.

PREVENTION OF VENTILATOR COMPLICATIONS

The frequency of complications from MV in the CICU has not been well studied, but complications occur in 20% to 30% of ventilated patients in general ICUs.[71] Common MV complications include ventilator-associated lung injury (VALI), muscle weakness, pressure ulcers, tracheal trauma, swallowing dysfunction, and hemodynamic instability. VALI refers to lung damage caused by invasive MV and is characterized by inflammation, hyaline membrane formation, and increased vascular permeability. This includes volutrauma (from alveolar overdistension), atelectrauma (from repetitive alveolar opening and closing), and barotrauma (from elevated airway pressure).[72] The risk of VALI is associated with patient respiratory mechanics and with MV settings such as tidal volume (TV), driving pressures, and positive end-expiratory pressure (PEEP).[72] Given the growing prevalence of MV in tertiary CICU population, an understanding of safe MV parameter limits may help to prevent VALI.

Tidal Volume

TV is defined as the volume of gas that is inhaled and exhaled during a respiratory cycle. The use of low TV ventilation has been effective in minimizing VALI complicating ARDS and has been shown to be safe in non-ARDS populations, including patients with cardiac arrest.[73,74] Although the incidence of ARDS in the CICU has not been widely reported, it is likely lower than that of a general ICU population given that patients in the CICU are typically admitted with a primary cardiac diagnosis.[75] Little is known about the optimal TV in a CICU population, and extrapolation from noncardiac cohorts may be inappropriate. Low TV ventilation is associated with an increased risk of patient-ventilation dyssynchrony, potentially resulting in a greater use of sedation. This, in turn, could increase the risk of hypercapnia, which has the potential of being harmful in patients after cardiac arrest by adversely affecting cerebral blood flow.[76] Thus, optimizing minute ventilation may limit potential shifts in cerebral vascular tone, and defining the optimal CO_2 level is currently an area of active research.[77] In addition, the hemodynamic impact of low TV ventilation on outcomes in patients in the CICU has not yet been explored. However, the PReVENT trial (Protective Ventilation in Patients Without *ARDS*), which included 961 patients without ARDS who were admitted to general ICUs, demonstrated no difference in mortality, ICU length of stay, or ventilator complications in patients with low TV (4–6 mL/kg ideal body weight) versus intermediate TV (≈10 mL/kg ideal body weight). In this study, 3% to 6% of patients had heart failure and 23% to 24% had cardiac arrest, but

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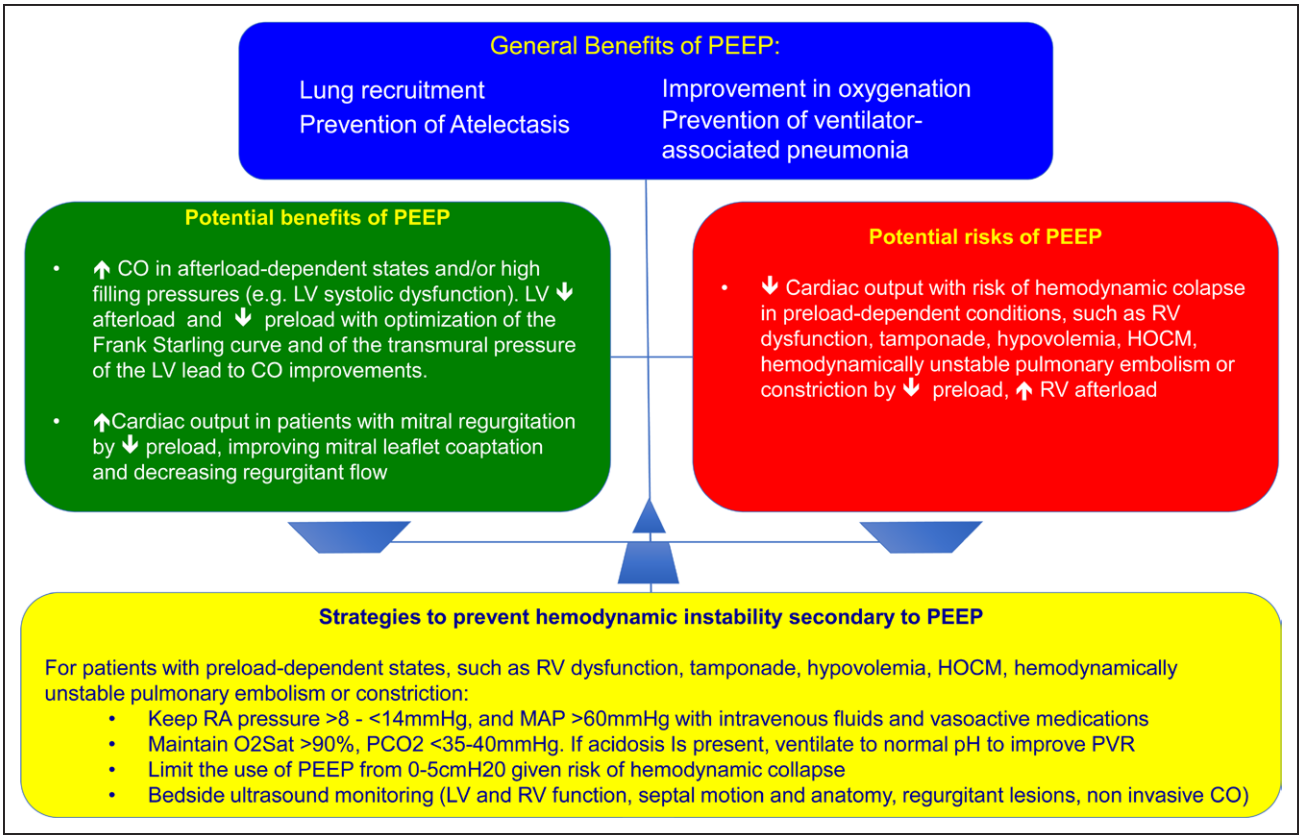

Figure 2. Bedside approach for positive end-expiratory pressure (PEEP) use and monitoring.
CO indicates cardiac output; HOCM, hypertrophic obstructive cardiomyopathy; LV, left ventricle; MAP, mean arterial pressure; Pco_2, partial pressure of carbon dioxide; PEEP, positive end-expiratory pressure; PVR, pulmonary vascular resistance; RA, right atrial; and RV, right ventricle.

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outcomes in these subgroups were not reported.[78] Finally, although no absolute threshold exists, a plateau pressure ≤30 cm H_2O is preferred by most intensivists and has been associated with decreased mortality in ARDS.[79]

Suggestion for CICU Practice

- When feasible, we suggest a routine TV of 6 to 10 mL/kg ideal body weight in the CICU, with lower TV (6–8 mL/kg ideal body weight) for patients at high risk of VALI or with established ARDS.

Positive End-Expiratory Pressure

PEEP quantifies airway and alveolar pressure above atmospheric pressure at the end of expiration. Applied PEEP is used to prevent atelectasis and to improve lung recruitment and oxygenation during positive pressure ventilation (PPV). PEEP may decrease the risk of VAP[80] and can improve hemodynamics in patients with left ventricular (LV) systolic dysfunction and elevated filling pressures by decreasing LV preload and afterload. In patients with afterload-sensitive LV performance (eg, classic cardiogenic shock, low-output heart failure, severe mitral regurgitation, ventricular septal rupture), limited data suggest that moderate applied PEEP (5–10 cm H_2O) has the potential to increase cardiac output by decreasing afterload via augmentation of the transmural intracardiac pressures of the LV and the intrathoracic aorta in relationship with the systemic circulation, by decreasing mitral regurgitant flow, and by improving forward flow.[81,82] Conversely, in patients with preload-dependent conditions such as right ventricular dysfunction, constriction, or tamponade, PEEP can worsen hemodynamics and lead to adverse outcomes by increasing right ventricular afterload and decreasing preload. These same populations of patients often tolerate PPV very poorly, and measures to avoid intubation should be considered when appropriate. Individual hemodynamic responses to the institution of PPV vary, depending on the patient's underlying cardiovascular diagnosis, right ventricular and LV function, volume status, and other comorbidities[82] (Figure 2). To date, the evidence generated to support the use of low versus high PEEP has been drawn primarily from an ARDS population, and the effects of different levels of PEEP on outcomes in patients in the CICU remain uncertain.[79] Therefore, titration of PEEP to improve physiology in patients in the CICU with cardiac dysfunction is reasonable but should be tailored to the patient's underlying condition and ventricular function.

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Suggestion for CICU Practice

- We suggest that the applied PEEP level should be tailored to each patient's underlying pathophysiological condition and adjusted to achieve oxygenation and hemodynamic targets. Higher PEEP (eg, 5–10 cm H_2O) can be considered in patients with LV dysfunction and elevated filling pressures. A lower PEEP (3–5 cm H_2O) may be appropriate for patients with right ventricular dysfunction, pericardial tamponade, constriction, and hypovolemia to prevent hemodynamic instability.

Oxygen Supplementation

Hyperoxia, defined as partial pressure of oxygen (Pao_2) >120 mm Hg (moderate, >200 mm Hg; severe, >300 mm Hg), is associated with adverse outcomes in the critically ill population.[83,84] Although the frequency of hyperoxia in the CICU is not well known, up to 80% of patients admitted to the hospital and ≈50% of those in general critical care settings may be exposed to excessive oxygen supplementation.[83] Although there is no specific definition of hyperoxia based on oxygen saturation (Spo_2) alone, the risk increases when Spo_2 is >95% with supplemental oxygen.[83] Hyperoxia can lead to systemic, cerebral, and coronary vasoconstriction and impaired myocardial function[85]; can promote myocardial apoptosis; and may result in direct tissue toxicity via the production of reactive oxygen species.

The optimal approach to oxygen administration continues to evolve. In normoxic patients after myocardial infarction, routine use of supplemental oxygen did not provide incremental benefit over usual care, with a signal for greater adverse events.[86,87] Among a cohort of patients in the ICU admitted postoperatively or with neurological conditions, conservative oxygen supplementation demonstrated no benefit in ventilator-free days compared with usual care.[88] However, there were no significant differences in the Pao_2 or Spo_2 between the 2 groups. Similarly, among patients with ARDS, early exposure to a conservative oxygenation strategy did not improve survival.[89] Prospective registries and meta-analyses of patients after cardiac arrest have shown that a Pao_2 >300 mm Hg during the first 6 hours is associated with worse neurological outcomes and other complications compared with a Pao_2 of 150 to 200 mm Hg.[69,90] This correlates with general ICU data showing that oxygen supplementation in patients with Spo_2 of 94% to 96% is associated with mortality.[83]

Suggestion for CICU Practice

- We suggest closely monitoring oxygenation in the CICU and titrating supplemental oxygen to achieve Spo_2 >90% or Pao_2 >60 mm Hg; hyperoxia (Pao_2 >150 mm Hg) should be avoided.

Daily SBTs and Other Strategies for Successful Extubation

SBTs are periods to test the patient's ability to breathe while receiving minimal or no ventilatory support. Performance of a daily SBT allows early identification of patients who are ready for MV liberation and is both safe and efficacious in reducing MV duration.[91] The ABC trial (*Awakening and Breathing Controlled*) demonstrated that patients receiving spontaneous awake trials or SBTs had significantly improved survival compared with those receiving standard care.[92] In contrast, the SLEAP trial (Daily Sedative Interruption in Critically Ill Patients Being Managed With a Sedation Protocol), which evaluated protocolized sedation versus protocolized sedation plus DSI, found no difference between groups with regard to time to extubation or duration of ICU and hospital stays.[64] This neutral result is likely related to both SLEAP groups receiving relatively high sedative doses and highlights the need to avoid deep sedation if possible.[93] SBTs should take place when readiness criteria are met, including reversal of the cause of respiratory failure, manageable secretions, adequate gas exchange without excessive effort, and mental status allowing patient participation. Hemodynamic stability is another prerequisite; however, low-dose vasopressor use is not a contraindication to weaning.[94]

SBTs can be performed by nurses or respiratory therapists using a spontaneous ventilator mode with minimal support, including pressure support ventilation with inspiratory pressure augmentation (5–8 cm H_2O) plus PEEP or without inspiratory pressure augmentation (with PEEP alone as continuous positive airway pressure). Alternatively, the patient can be disconnected from the circuit while maintaining an oxygen source to the endotracheal tube (T-piece). SBT with pressure augmentation is associated with successful extubation and a trend toward lower mortality.[91] A recent clinical trial in general ICUs in which >25% of patients had cardiovascular disease demonstrated lower rates of reintubation and lower mortality in patients who underwent SBT with pressure support for 30 minutes compared with a T-piece for 2 hours.[95] Moreover, an SBT with a T-piece has the potential to increase LV afterload and myocardial oxygen consumption and may worsen hemodynamics in patients with LV failure, ischemia, or valvular regurgitation.

In addition to standardized SBT protocols, tools to predict extubation success (and to avoid reintubation) include a rapid shallow breathing index (the ratio of respiratory rate to TV in liters) <105, a strong cough, or a negative inspiratory force <–30 cm H_2O (Figure 3). It is important to evaluate whether the patient is at risk of postextubation stridor. Risk factors include MV for >6 days, female sex, large endotracheal

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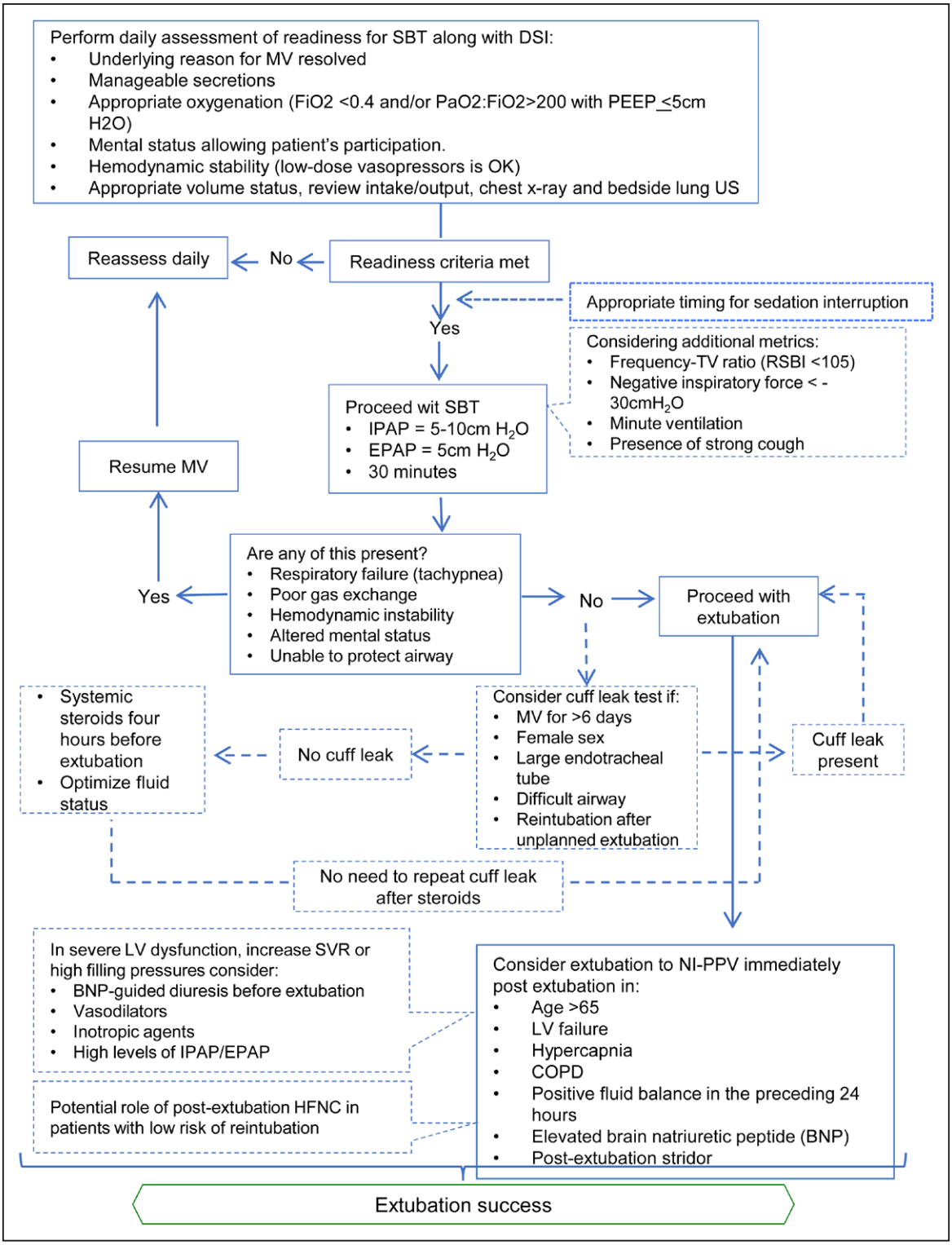

Figure 3. Algorithm for liberation from mechanical ventilation (MV) in the cardiac intensive care unit.
BNP indicates brain natriuretic peptide; COPD, chronic obstructive pulmonary disease; DSI, daily sedation interruption; EPAP, expiratory positive airway pressure; F_{IO_2}, fraction of inspired oxygen; HFNC, high-flow nasal cannula; IPAP, inspiratory positive airway pressure; LV, left ventricular; NI-PPV, noninvasive positive-pressure ventilation; PEEP, positive end-expiratory pressure; RSBI, rapid shallow breathing index; SBT, spontaneous breathing trial; SVR, systemic vascular resistance; TV, tidal volume; and US, ultrasound.

tube, or unplanned extubation. In these cases, performing a cuff-leak test, administering prophylactic steroids when indicated, or optimizing fluid status is appropriate as recommended by the American Thoracic Society/American College of Chest Physicians guidelines.[96]

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Suggestion for CICU Practice

- We suggest performing a daily assessment for readiness for extubation on every patient undergoing MV, including a protocolized SBT.[91,96]

Appropriate Use of Noninvasive PPV

Noninvasive PPV (NI-PPV) includes high-flow nasal cannula (HFNC), continuous positive airway pressure, and bilevel positive airway pressure. Appropriate use of NI-PPV may be associated with fewer ventilation-related complications compared with invasive mechanical PPV such as hemodynamic instability resulting from intubation and sedation, upper airway trauma, delirium, VAP, and VALI. HFNC is a potential first-line option in selected patients with hypoxemic respiratory failure (eg, acute pulmonary edema, particularly if there is no significant acidosis, hypercapnia, altered level of consciousness, or increased work of breathing) in patients receiving conventional oxygen because of its ability to provide high fraction of inspired oxygen (FIO_2) and limited PEEP (up to 3–5 cm H_2O[97]). For patients with more severe respiratory failure, bilevel positive airway pressure or continuous positive airway pressure can provide higher levels of support and may provide hemodynamic benefits in patients with LV failure. Bilevel positive airway pressure provides both inspiratory and expiratory pressure (expiratory positive airway pressure and PEEP) augmentation and is preferred for treatment of hypercarbic respiratory failure.[98] NI-PPV is not recommended for patients who are unable to protect their airway, those with facial deformities or trauma, those with emesis and copious secretions, and those with recent surgery of the upper airway or gastrointestinal tract.[98]

Compared with conventional oxygen supplementation alone, NI-PPV use can help reduce in-hospital mortality and the need for invasive, endotracheal intubation in selected patients such as those with acute pulmonary edema.[99] Understanding the indications and contraindications for NI-PPV and the methods for closely monitoring minute ventilation, patient-device synchrony, air leaks, mental status changes, hemodynamic perturbations, and alterations in gas exchange is key to limiting complications with bilevel positive airway pressure/continuous positive airway pressure in the CICU (Supplemental Table 1).[82,100] Postextubation NI-PPV can prevent complications during MV liberation in the CICU, particularly in patients with risk factors for reintubation such as those with LV failure, hypercapnia, chronic obstructive pulmonary disease, positive fluid balance, elevated BNP (brain natriuretic peptide), postextubation stridor, and age >65 years.[91,96,101] The combination of NI-PPV and HFNC after extubation led to lower reintubation rates compared with HFNC alone in a recent clinical trial based in general ICUs, but nearly 50% of patients had chronic heart disease (ischemic heart disease, LV dysfunction, and atrial fibrillation), potentially reflecting a CICU population.[102] Similarly, given the adverse hemodynamic effects that can occur immediately with PEEP withdrawal (increase preload and increase afterload), NI-PPV can be used in combination with diuretics, vasodilators, and inotropic agents to offset these effects and thus to prevent postextubation pulmonary edema (Figure 3).[101]

Suggestions for CICU Practice

- We suggest using HFNC or NI-PPV in appropriately selected patients in the CICU with respiratory failure to reduce morbidity and mortality and to minimize the need for invasive, endotracheal intubation.
- We suggest that NI-PPV should be considered after extubation for patients at risk for reintubation.

Intubation/PPV–Associated Hemodynamic Compromise

To prevent hemodynamic complications from PPV, it is important to understand the specific patient profile, underlying hemodynamics, and ventricular function. The use of invasive hemodynamic monitoring along with bedside echocardiography with Doppler analysis can help in patient evaluation. When possible, optimizing mean arterial pressure and preload with fluids or vasoactive agents and avoiding hypoxemia, hypercapnia, or acidosis can prevent hemodynamic compromise during induction and intubation. In patients with tenuous hemodynamics, pursuing an awake intubation technique by an expert in airway management may prevent further decompensation, but this approach has not been evaluated systematically.

Suggestion for CICU Practice

- We suggest individualizing induction and intubation practices according to patient hemodynamics, ventricular function, and loading conditions. Prior stabilization of vital signs, if possible, can mitigate some of the effects of intubation and MV initiation.

BENEFITS OF EARLY MOBILIZATION

ICU-acquired weakness, defined as a clinically appreciable myopathic or neuropathic weakness that develops in the absence of other factors besides critical illness, occurs in as many as one-third of patients in the ICU and has been associated with decreased survival.[103] Bed rest is a major risk factor for ICU-acquired weakness. This has prompted many societies, including the Society of Critical Care Medicine and American College of Chest Physicians, to recommend early, progressive mobilization of patients in the ICU.[53] In fact, early mobilization is a component of the ABCDEF bundle (Figures 1 and 4).

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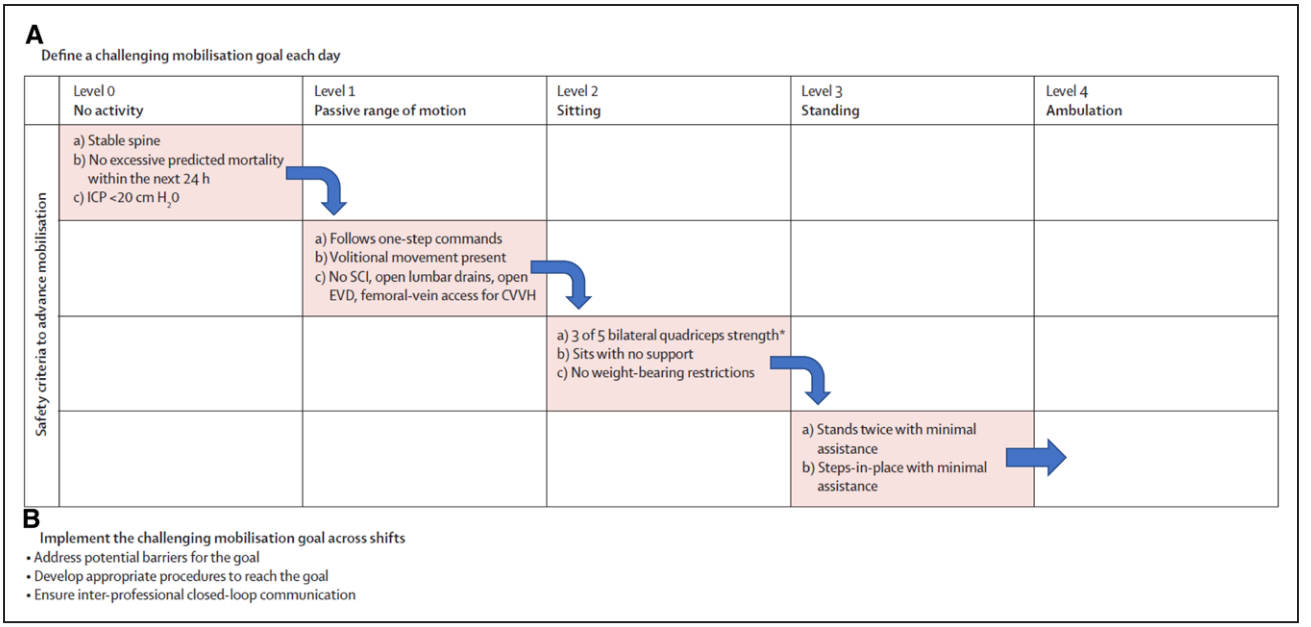

Figure 4. Example of an early, goal-directed mobilization protocol.
Protocol used (**A**) daily definition of a mobility goal (level 0–4) based on daily examination and an assessment of safety criteria, followed by (**B**) implementation of mobilization therapy. Target mobilization was posted at the patient's bedside, and any barriers to successful implementation were identified by a facilitator through multiprofessional closed-loop communication. CVVH indicates continuous veno-venous hemofiltration; EVD, extracranial ventricular drain; ICP intracranial pressure; and SCI, spinal cord injury. Reprinted from *The Lancet*, Schaller et al,[104] with permission from Elsevier. Copyright © 2016, Elsevier.

Defining Mobilization

Mobilization is typically defined as a type of rehabilitation intervention that facilitates movement and energy expenditure in patients with the goal of improving outcomes.[53] Although the specific mobilization program will vary according to patient and site characteristics (eg, mechanically ventilated, type of ICU, practitioner availability), mobilization typically involves a staged progression of passive range of motion, active range of motion, sitting, standing, and ambulation. One protocol, described by Schaller and colleagues[104] (Figure 4), encouraged defining a daily mobility goal on the basis of the examination during rounds. After multidisciplinary agreement, the plan was implemented with facilitated, closed-loop feedback if barriers to mobilization were identified.

Potential Benefits of Early Mobilization

Some small randomized studies have suggested that early mobilization of patients in the ICU may minimize weakness, improve physical functioning, prevent delirium, decrease duration of MV, and shorten ICU length of stay without a significant difference in mortality.[104–106] In an international assessor-blinded trial, 200 surgical patients with MV in the ICU were randomized to the previously described mobilization protocol (Figure 4) or standard treatment.[104] Patients receiving goal-directed mobilization demonstrated improved mobilization, as assessed by the mean mobilization level, more delirium-free days, decreased ICU length of stay (7 days versus 10 days), and improved functional independence at discharge (44% versus 25%). There was no difference in duration of MV or quality of life 3 months after discharge. The intervention group had more adverse events, but in-hospital mortality did not differ between the intervention and control arms. Similarly, in a multicenter medical ICU study, 104 patients with MV were randomized to early mobilization, inclusive of physical and occupational therapy during DSI, versus standard therapy.[106] There was a significant improvement in the primary end point of return to independent functional status at hospital discharge (59% versus 35%), as well as fewer days with delirium (2 versus 4) and a decrease in days of MV (3.4 days versus 6.1 days), without a difference in ICU length of stay or hospital mortality. In contrast, a single-center randomized study of 300 patients with acute respiratory failure requiring MV randomized to daily standardized rehabilitation versus usual care did not show a difference in length of stay, duration of MV, measures of physical function, or quality of life.[105] Discrepant findings may be explained by the inclusion of a more chronically ill population, a longer duration of MV at the time of randomization, and the lack of a sedation protocol. Recent observational studies from CICUs have demonstrated both feasibility and success for early mobilization in this setting, including among frail patients and with a nurse-driven protocol.[107,108]

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Table 5. Guidance for Initiation and Stopping Criteria for Mobilization in the CICU

System	In-Range Parameters for Initiation of Therapy	Potential Stopping Criteria
Cardiovascular	Heart rate between 50 and 130 bpm	Development of significant derangement in cardiovascular parameters outside of recommended range
	Systolic blood pressure between 80 and 170 mm Hg	
	Mean arterial pressure between 60 and100 mm Hg	
	Absence of unstable or symptomatic arrhythmia, ischemic symptoms	
Respiratory	Stable/secured airway, including endotracheal tube or tracheostomy (ie, MV is not a contraindication to mobilization)	Development of significant derangement in respiratory parameters outside of recommended range or ventilator dyssynchrony
	Respiratory rate between 5 and 30 breaths/min	
	Spo_2 ≥88% (assuming baseline Spo_2 not chronically low)	
	Flo_2 <0.6 and PEEP ≤10 cm H_2O	
	Not in prone positioning	
Neurological	Absence of severe agitation (eg, RASS score >+2)	Changes in consciousness or agitation that interfere with safe mobilization
	Absence of spinal precautions/unstable spinal injury, elevated intracranial pressure, uncontrolled seizures	
Other	Absence of unstable fractures, uncontrolled bleeding	Intermittent hemodialysis (but not necessarily continuous renal replacement therapy)
	Significant titration of vasoactive agents not required (ie, infusion of vasoactive agents is not a contraindication to mobilization)	Fall
		Medical device removal/malfunction
	Secured vascular access; certain femoral access may preclude lower-extremity mobilization or ambulation	

CICU indicates coronary intensive care unit; Flo_2, fraction of inspired oxygen; MV, mechanical ventilation; PEEP, positive end-expiratory pressure; RASS, Richmond Agitation-Sedation Scale; and Spo_2, oxygen saturation.

Adapted from Hodgson et al.[110] Copyright © 2014, Hodgson et al.; licensee BioMed Central. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited. Adapted from Devlin et al[53] with permission. Copyright © 2018, by the Society of Critical Care Medicine and Wolters Kluwer Health, Inc.

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Safety and Risks of Early Mobilization

Early mobilization, whether in bed or out of bed, is generally safe and poses relatively few risks to the patient. A meta-analysis of 48 randomized and observational studies in >5800 patients and 16 000 rehabilitation sessions reported low rates of falls (0.07%), endotracheal tube removal (0.01%), removal or dysfunction of an intravascular catheter (0.2%), hemodynamic changes (0.7%), and desaturations (0.5%).[109] Another meta-analysis found that serious safety events, defined as a change in physiological status or an injury that required an intervention, were rare at a rate of ≈0.1% (15 events during >12 200 sessions across 13 studies).[53]

Patient Eligibility for Early Mobilization and Criteria for Termination of Therapy

The criteria for inclusion of patients in studies of early mobilization have varied, although most studies have been fairly inclusive with few absolute contraindications to mobilization. Absolute contraindications to mobilization typically included unstable fractures, acute myocardial infarction or active ischemia (eg, nonrevascularized, ongoing chest pain, dynamic electrocardiographic changes), raised intracranial pressure, or uncontrolled bleeding. Beyond these, clinical judgment is necessary to individualize the decision to initiate or terminate therapy. Guidance is provided in Table 5, which integrates parameters used in clinical studies and expert opinion. In general, patients should demonstrate cardiovascular, respiratory, and neurological stability; however, vasoactive agent infusion, MV, intravascular catheters, MCS, including ECMO, and altered mental status do not universally preclude the initiation of early mobilization.[111,112] It is reasonable to discontinue mobilization if significant neurological, cardiovascular, or respiratory derangements such as agitation, hypotension, desaturations, or ventilator dyssynchrony occur. Furthermore, mobilization should be aborted if falls or displacement or malfunction of lines or devices occurs.

Conclusions

The limited available evidence suggests that early mobilization is feasible and may have a beneficial impact on outcomes such as physical functioning, duration of MV, delirium management, and length of stay. No data are available on the efficacy and safety of early mobilization in the CICU, pointing to a need for high-quality randomized data in critically ill cardiac patients. In the absence of CICU-specific data and in light of the limited

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Table 6. Candidacy for Early Enteral Nutrition

Early Enteral Nutrition Is Suggested	Enteral Nutrition Can Be Delayed
Compensated shock with low, stable, or decreasing vasopressor requirements and resolved lactic acidosis	Decompensated shock with high or rising vasopressor requirements and persistent or worsening lactic acidosis
Respiratory failure when hypoxemia, hypercarbia, and acidosis are controlled or improving, including compensated or permissive hypercapnia	Uncontrolled life-threatening hypoxemia, hypercapnia, or acidosis
Patients with traumatic brain injury, stroke, spinal cord injury, severe pancreatitis, after gastrointestinal surgery, after abdominal aortic surgery, after abdominal trauma (when gastrointestinal continuity is present), open abdomen, intra-abdominal hypertension, resolved gastrointestinal bleeding, compensated liver failure, diarrhea	Patients with overt bowel ischemia, high-output intestinal fistula, discontinuous gastrointestinal tract, abdominal compartment syndrome, active gastrointestinal bleeding, metabolically decompensated liver failure, immediately after upper gastrointestinal surgery
Patients receiving sedative or analgesic medications, including NMB, even without bowel sounds	Patients with gastric residual volumes >500 mL/6 h (routine monitoring of gastric residual volumes is not typically necessary)
Patients after TTM rewarming, ECMO, or prone positioning	

ECMO indicates extracorporeal membrane oxygenation; NMB, neuromuscular blocker; and TTM, targeted temperature management.
Data derived from Reintam Blaser et al[114] and McClave et al.[115]

risk and potential benefits in other ICU populations, we believe that extrapolation to the CICU is reasonable.

Suggestions for CICU Practice

- We suggest routinely incorporating early mobilization protocols into management plans for patients in the CICU. Eligibility for early mobilization may be assessed daily with a multidisciplinary team, including physician, nursing, and rehabilitation team members.
- We suggest early mobilization for the majority of patients except those with active ischemia or infarction. The use of vasoactive agents, MV, intravascular catheters, and mechanical support devices and altered mental status do not preclude early mobilization. Discontinuation of a therapy session is reasonable if significant neurological, cardiovascular, or respiratory derangements occur.

PREVENTION OF GASTROINTESTINAL COMPLICATIONS

Feeding

The prevalence of malnutrition in patients admitted to the ICU is high (range, 38% to 78%), and malnutrition is associated with adverse outcomes, including increased ICU length of stay, readmission, infection, and hospital mortality.[113] Dedicated CICU literature is lacking, but recent professional society guidelines on the nutritional support of critically ill patients are likely applicable to CICU populations.[114,115] Compared with either delayed enteral feeding or early parenteral nutrition, early enteral feeding is safe and may reduce the risk of infection by preserving gut mucosal integrity and preventing bacterial translocation.[114] Early initiation of enteral nutrition (within 24–48 hours of admission) is suggested in the majority of patients who are unable to eat. Enteral feeding should begin with low (trophic) doses (typically 10–20 mL/h of a standard polymeric formula) and increased as tolerated.[114,115] There are relatively few contraindications to early trophic enteral feedings (Table 6), and trophic enteral feeding is reasonable in patients with compensated or resolving shock, those undergoing TTM, and those with compensated respiratory failure (including stabilized patients receiving prone positioning or ECMO).[114]

Caloric requirements among critically ill patients are estimated at 25 to 30 kcal·kg^{-1}·d^{-1} including 1.2 to 2 g/d protein (up to 2.5 g·kg^{-1}·d^{-1} in patients receiving continuous renal placement therapy). Full caloric feeding may not be required for up to 6 days in patients without baseline nutritional deficiency, and permissive underfeeding (40%–60% of caloric needs) may be preferable in these patients; for patients at high nutritional risk (based on a nutritional risk score), escalation of enteral feedings to >80% of goal within 48 to 72 hours is advised.[115] Early full caloric enteral feeding (ie, 25 kcal·kg^{-1}·d^{-1} within the first 24 hours) does not appear to be beneficial and may increase the risk of gastrointestinal complications, including bowel ischemia and colonic pseudo-obstruction.[116]

In general, parenteral nutrition should be avoided except in patients unable to meet >60% of caloric requirements after 7 to 10 days via the enteral route. Patients at high nutritional risk based on validated risk scores (eg, Nutritional Risk Score [Numeric Rating Scale 2002]) may be considered for earlier initiation of parenteral nutrition (within 24–72 hours) if they are unable to meet their caloric needs with enteral nutrition.[115] Gastric feedings are recommended for patients who are not at high aspiration risk; if tube feeding intolerance occurs, prokinetic agents such as metoclopramide or erythromycin can be used, with postpyloric feeding tube placement if these agents are ineffective or contraindicated.[114,115] Gastric residual volume monitoring during enteral nutrition does not appear to reduce rates of aspiration or pneumonia as long as the head of the bed remains elevated >30°. Interruptions in enteral feeding should be minimized.[115]

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No studies support the routine use of specialized formulas or nutritional supplements in the majority of CICU patient populations, although a fluid-restricted calorie-dense formula may be reasonable for patients with acute kidney injury or decompensated heart failure.[115]

Gastrointestinal Bleeding Prophylaxis

Stress ulcers, defined as upper gastrointestinal tract ulcerations that occur as a result of illness during a hospitalization, are common in the ICU setting. Overt bleeding (hematemesis, melena, or nasogastric tube aspirate with frank blood or coffee grounds) can occur in 2% to 4% of general ICU patients[117,118]; the incidence may be higher in a CICU setting where most patients are on antiplatelet medicines or anticoagulants. Because of the significant morbidity and mortality associated with stress ulcers, routine stress ulcer prophylaxis in the ICU became common despite a lack of evidence. Newer evidence suggests that stress ulcer prophylaxis may be associated with reduced gastrointestinal bleeding in high-risk patients but overall has no demonstrated mortality benefit, and the number needed to treat is high.[117,119,120] Routine use of stress ulcer prophylaxis is not necessary for low-risk patients in the CICU, including all patients receiving MV. Stress ulcer prophylaxis is reasonable for patients in the CICU with multiple risk factors for gastrointestinal bleeding (including patients with shock, acute kidney injury requiring renal replacement therapy, MV, liver disease, use of anticoagulants, and ongoing coagulopathy as defined by platelet count <50 000/m^3, an international normalized ratio >1.5, or a partial thromboplastin time >2 times the control value or on dual antiplatelet therapy), although the data supporting this approach are weak.[117,119,120]

Concerns have been raised that stress ulcer prophylaxis may increase the risk of infectious complications such as CDI or pneumonia, although this remains controversial.[117,119,120] Further uncertainty exists in regard to the optimal agent for prophylaxis. In general, proton pump inhibitors (PPIs) have greater efficacy for preventing gastrointestinal bleeding. Although histamine-2 receptor antagonists have a lower risk of infectious complications, they are associated with a higher risk of thrombocytopenia and may be less optimal in the CICU.

Very limited data support the use of stress ulcer prophylaxis in patients on ECMO or MCS, although these patients are likely at increased risk for gastrointestinal bleeding, and therefore, stress ulcer prophylaxis with a PPI is reasonable.[118] The role of stress ulcer prophylaxis for patients in the CICU receiving antiplatelet agents and anticoagulants is also unclear. However, because current American College of Cardiology Foundation/American Heart Association recommendations support the long-term use of PPIs in patients on oral dual antiplatelet therapy with a high risk for gastrointestinal bleeding (prior gastrointestinal bleeding, advanced age, *Helicobacter pylori* infection),[121] starting a PPI in the CICU for this population is reasonable. Similarly, for patients requiring dual or triple antithrombotic therapy (single antiplatelet therapy or dual antiplatelet therapy plus an anticoagulant such as heparin, warfarin, or a direct oral anticoagulant), we suggest initiating a PPI in the CICU. In addition, it may be reasonable to use a PPI with less CYP2C19 inhibition (eg, pantoprazole) instead of a PPI with higher CYP2C19 inhibition (eg, omeprazole) in patients receiving clopidogrel.[122]

Hyperglycemia Management and Prevention of Hypoglycemia

In both medical and surgical ICU settings, hyperglycemia is common and has consistently been linked to increased mortality; therefore, treatment of severe hyperglycemia is warranted. However, the target blood glucose range is less clear and may depend on the patient's baseline glycemic status, including the presence and prior control of diabetes mellitus. Overall, intensive insulin therapy targeting a blood glucose level of 80 to 110 mg/dL (4.4–6.1 mmol/L) has been shown to increase the incidence of hypoglycemia and mortality compared with blood glucose targets <180 mg/dL (<10 mmol/L) in medical ICU populations.[123,124] These data on intensive insulin therapy may be extrapolated to medical patients in the CICU, although limited data may support the use of intensive insulin therapy in patients after cardiac surgery.[123]

In the CICU, we suggest starting insulin therapy when blood glucose levels are >150 mg/dL (8.3 mmol/L). We advocate for intravenous insulin in patients with high illness severity, although subcutaneous insulin may be reasonable in select stable patients, particularly those who are eating. Insulin therapy should target blood glucose levels <180 mg/dL (10 mmol/L) and ideally <150 mg/dL (8.3 mmol/L) instead of stricter control (80–110 mg/dL [4.4–6.1 mmol/L]).[123] It is reasonable to titrate insulin therapy to a blood glucose target of 140 to 180 mg/dL (7.7–10 mmol/L) in the CICU with frequent glycemic monitoring and an institutional insulin protocol. A moderate glycemic target avoids the risk of hypoglycemia and mortality linked to both more stringent targets and complications associated with more liberal targets. Similar to the development of an institutional protocol for hyperglycemia, an institutional protocol for the treatment of hypoglycemia (blood glucose level <70 mg/dL [3.9 mmol/L]) also should be implemented.[123]

Suggestions for CICU Practice

- We suggest early initiation of enteral nutrition (within 24–48 hours of admission) in the majority

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of patients who are unable to eat. Trophic enteral feeding is reasonable in most patients in the CICU, even those with compensated shock, those undergoing TTM, and those with compensated respiratory failure (including stabilized patients receiving prone positioning or ECMO).

- It is reasonable to administer stress ulcer prophylaxis for patients at increased risk of gastrointestinal bleeding, including patients on dual antiplatelet therapy with high-risk features or patients on triple antithrombotic therapy.
- We suggest starting insulin therapy when blood glucose levels are >150 mg/dL (8.3 mmol/L), and for critically ill patients, we recommend intravenous insulin over subcutaneous insulin.[123] It is preferable to titrate insulin therapy to a blood glucose target of 140 to 180 mg/dL (7.7–10 mmol/L).

PREVENTION AND RECOGNITION OF MEDICATION COMPLICATIONS AND ERRORS

The medication use process is the most common source of serious medical errors in the ICU setting, accounting for 78% of serious medical errors in 1 study,[125] and thus represents an important target for the prevention of complications. Medication errors (defined as an error at any point from ordering to administering medications) and adverse drug events (defined as patient harm resulting from exposure to a medication) are more common in the ICU and carry a greater likelihood of harm compared with such events in the non-ICU setting.[126] Cardiovascular medications and anticoagulants are the 2 most common medication classes associated with adverse events and medical errors in the ICU setting, highlighting the high-risk nature of medications routinely used in the CICU.[125] Recent guidelines to prevent complications include the use of computerized physician order entry, bar code medication administration, the use of bundles/protocols, and the use of smart intravenous infusion pumps to reduce the risk of medication errors and adverse drug events.[126] Last, the addition of pharmacists to the ICU rounding team has previously been shown to reduce the number of preventable adverse drug events,[127] and clinical pharmacy services in the CICU have been associated with a significant reduction in total drug costs.[128] However, CICU-specific best practices for preventing medication process errors remain to be defined.

Anticoagulation

Anticoagulant therapy is frequently prescribed in the CICU for acute coronary syndromes, stroke prophylaxis in atrial fibrillation, systemic thromboembolism, and prophylaxis of thrombosis in patients receiving MCS. Unfractionated heparin is often used in the CICU because of its short duration of action, but its administration may be prolonged, especially in the setting of MCS, and high rates of thrombocytopenia have been reported in patients receiving unfractionated heparin for ≥96 hours in the CICU.[129] Clinical suspicion for heparin-induced thrombocytopenia is often high in these patients, and with a moderate or high probability of heparin-induced thrombocytopenia, heparin therapy (including unfractionated or low-molecular-weight heparin) should be discontinued and an alternative anticoagulant agent (such as an intravenous direct thrombin inhibitor) should be initiated while diagnostic testing results are awaited.[130]

With the initial selection and dosing of anticoagulant therapy in the ICU population, consideration should be given to patient-specific factors, including age, body weight, renal and hepatic function, and the future need for invasive procedures and MCS. Patients in the CICU often have acute organ dysfunction, especially those with cardiogenic shock or cardiac arrest. The pharmacokinetic and potential pharmacodynamic changes associated with anticoagulant therapy in these settings make evidence-based agent selection, dosing, and monitoring imperative in an effort to minimize the potential for adverse events such as bleeding. The National Patient Safety Goals for anticoagulant therapy include a requirement that institutions establish an evidence-based guideline for the management of anticoagulant-associated bleeding events.[9]

Antiarrhythmic Therapy

Antiarrhythmic drugs (AADs) are frequently prescribed in patients in the CICU to treat or suppress supraventricular or ventricular tachyarrhythmias, but they have the potential to produce proarrhythmic effects, including life-threatening ventricular dysrhythmias, as well as extracardiac adverse effects and complex drug-drug interactions.[131] In addition, a recent analysis observed rates of QT prolongation of ≈40% in patients in the CICU.[132] Risk factors associated with AAD-induced polymorphic ventricular tachycardia (torsades de pointes) in hospitalized patients, including prolonged QTc interval, advanced age, heart failure, myocardial infarction, preexisting conduction disturbances, electrolyte imbalances, impaired hepatic or renal function, and use of multiple QT-prolonging medications, are very common in the CICU.[133] Strategies to prevent AAD-associated torsades de pointes in the patient in the CICU include carefully evaluating the ECG with QTc monitoring before and after AAD administration, maintaining serum potassium and magnesium in the normal range, dose-adjusting AADs on the basis of renal or hepatic function with pharmacokinetic monitoring when applicable, and avoiding other QT-prolonging

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medications.[131,133] Concomitant medication classes associated with QT prolongation often prescribed in the CICU include macrolide and quinolone antibiotics, azole antifungals, antidepressants, antipsychotics, antiemetics, and opioids; a comprehensive list can be found online.[134]

Vasoactive Medications

Vasopressors and inotropes are high-risk medications frequently prescribed in the CICU, approaching use in 40% of patients in tertiary centers.[62] Despite their widespread use, randomized controlled comparative safety and effectiveness data are limited. Although many agents have both vasoactive and inotropic effects, distinction among these intended effects may help guide drug selection in individual situations.[135] Monitoring for efficacy with titration to the lowest effective dose for safety purposes is required.[135]

Guidance on initial selection of vasoactive drugs is given in Table 5 of the scientific statement on the management of cardiogenic shock.[136] Strongly β-adrenergic catecholamines (dopamine, epinephrine) are associated with higher rates of arrhythmias and potentially worse outcomes when used at high doses as vasopressors in cardiogenic shock.[6,137] In the SOAP II trial (Sepsis Occurrence in Acutely Ill Patients), use of dopamine as a vasopressor was associated with higher rates of tachyarrhythmias and higher mortality compared with norepinephrine in a prespecified cardiogenic shock subgroup.[138] Given these results, the authors have suggested that norepinephrine may be the vasopressor of choice in many patients with cardiogenic shock.[136] However, as previously noted, study limitations such as the cardiogenic shock subgroup comprising various hemodynamic phenotypes have left questions about the preferred first-line vasoactive medication in patients with various cardiogenic shock subtypes. A more flexible approach with an emphasis on hemodynamic tailoring with the goal of improving perfusion, as well as consideration of MCS when appropriate, may be warranted.

Adverse effects of vasopressor medications can include tachyarrhythmias, myocardial ischemia, infusion-related tissue extravasation, mesenteric ischemia, and limb ischemia and necrosis.[135] Adverse effects of inotropes include tachyarrhythmias, myocardial ischemia, and hypotension, particularly with the use of inodilators in hypotensive patients or those who have received inadequate fluid resuscitation.[135] Careful titration of vasoactive medications, with assessment of the effects on tissue perfusion and the degree to which blood pressure and cardiac output targets are being achieved, can allow the use of the minimal effective dosage so as to minimize potential adverse effects.

Suggestion for CICU Practice

- For common CICU medications, we suggest a routine therapy-specific approach to prevent potential complications (Supplemental Table 2).

COMPLICATIONS OF INVASIVE CARDIAC PROCEDURES AND DEVICES

A hallmark of the CICU, compared with other ICUs, is the specialized use of invasive cardiovascular monitoring and support devices.[139,140] The increasingly sophisticated diagnostic and therapeutic procedures that can be used in the cardiac catheterization laboratory or at the bedside have transformed cardiovascular care and potentially improved mortality. However, with increased use come associated complications that relate both to the placement of the device and to its maintenance.[141–144] A central tenet of prevention of CICU complications from invasive procedures and devices is to avoid emergency procedures when possible. Rates of infections and other complications are higher when these devices and procedures are performed in emergency settings.[144] A detailed discussion of preventing infectious complications is provided earlier in this document (see the Prevention of CICU-Acquired Infections section). Supplemental Table 3 details potential complications and prevention strategies associated with common procedures performed in the CICU.

Suggestions for CICU Practice

- We suggest that, whenever possible, procedures should be performed before they become emergency, including the routine use of ultrasound and fluoroscopic guidance.
- We suggest prompt removal of any invasive catheter or MCS device when no longer needed.

TRANSITIONS OF CARE BEST PRACTICES

Multidisciplinary Rounding

Effective communication is essential for high-quality health care. Patient care rounds, in which healthcare providers communicate and make healthcare decisions, are especially important in a complex environment such as a CICU. Multidisciplinary rounds, involving physicians from different specialties and other healthcare providers, not only improve the satisfaction of nurses and allied health professionals but also have been associated with improved outcomes.[145] Bedside rounding, although it can increase rounding time, makes rounds more accessible to nurses and other providers while providing the structure to obtain their input about the plan of care.

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Table 7. Barriers to Best Practices in Multidisciplinary CICU Care and Strategies to Surmount Them

Barriers	Interventions
Large team size	Structured rounds
	Structured information transmission and structured handoffs
Variability in team membership	Interdisciplinary rounds, led by cardiac intensivists when possible
	Standardized rounding structure
	Standard protocols and policies when appropriate
	Structured handovers
Geographic dispersion of team members, within and outside of the hospital	Scheduled multidisciplinary rounds at a standard time that include all team members
Steep hierarchies that may inhibit questioning	Bottom-up team design that values all participants, including patient and family, and emphasizes democratic decision making
	Explicit roles for team members
	Daily goals-of-care checklists formulated on rounds with broad input
Asynchronous communication facilitated by information technologies	Structured CICU-based decision processes
	Closed-loop communication
	Face-to-face handoffs
Lack of training on interdisciplinary communication and teamwork	Teamwork training programs
	Team-building exercises

CICU indicates cardiac intensive care unit.

Coordination of complex multidisciplinary care plans is best facilitated by open communication among providers, patients, and families. Adding pharmacists to the rounding team has been shown to reduce adverse drug effects and may decrease costs.[145]

Standardized rounding processes with structured presentation and explicit definitions of the role of each healthcare provider increase both efficiency and healthcare provider satisfaction. A large cluster randomized clinical trial showed that inclusion of daily goal checklists during rounds improved the use of some (but not all) evidence-based ICU interventions.[146] Daily goal checklists can make discussions more oriented to prognosis and long-term goals and have been associated with increased team and patient satisfaction.[145]

Family presence in interdisciplinary rounds increases understanding, engagement, and satisfaction, and giving families the option to be present should be considered, although other ways of facilitating family involvement and communication, including routine interdisciplinary family conferences, should also be used.[147]

Regardless of the rounding structure, clear lines of communication among providers, patients, and families are essential for optimal care. The critical care team is often best positioned to integrate multiple inputs, translate them into therapeutic options, and then present and discuss these options with patients and families. This is particularly important in the CICU environment, in which decisions may need to be made in multiple locations such as the catheterization laboratory, operating room, and CICU. Although discussions and decisions are collaborative, a consistent message is best communicated by a single team that incorporates multiple views and explains the options, plan, and prognosis with clarity and consistency.

Some of the most important barriers to best practices in CICU care and strategies to surmount these barriers are listed in Table 7.

Palliative Care

Palliative care is not simply end-of-life care but rather an overall approach to care that focuses on improving quality of life, providing comfort, and reducing suffering for patients and families. Therefore, palliative care should not be initiated only as an option of last resort but rather can coexist with active and even invasive treatments up to the point of transition to end-of-life care and should be integrated into decision making and care plans early in the clinical course.[148] In particular, palliative care considerations should be included in decisions about advanced care options such as cardiac transplantation and MCS devices, both temporary and permanent, if only for planning contingencies should these therapies prove ineffective.

Although palliative care is multidisciplinary and palliative care skills represent a core competency for critical care physicians and heart failure specialists, subspecialty palliative care consultation can also be very useful. Specialists in palliative care are particularly skilled at helping patients and families navigate the difficult process of complicated advance care planning and goals-of-care discussions and may be particularly helpful in addressing differences in expectations among patients, families, and clinicians. Palliative care specialists also provide expertise in managing noncardiac symptoms and holistically improving quality of life. When appropriate, palliative care specialists can help to facilitate the transition to hospice.[148]

Role of Cardiac Intensivists

It is clear that the best outcomes in complex cardiac patients are not attributable to the efforts of individual physicians but rather those of well-trained, highly functioning teams that include members from many disciplines who communicate effectively. Contemporary care for critically ill cardiac patients will likely encompass a hub-and-spoke model with transfer of the sickest patients to regionalized centers of

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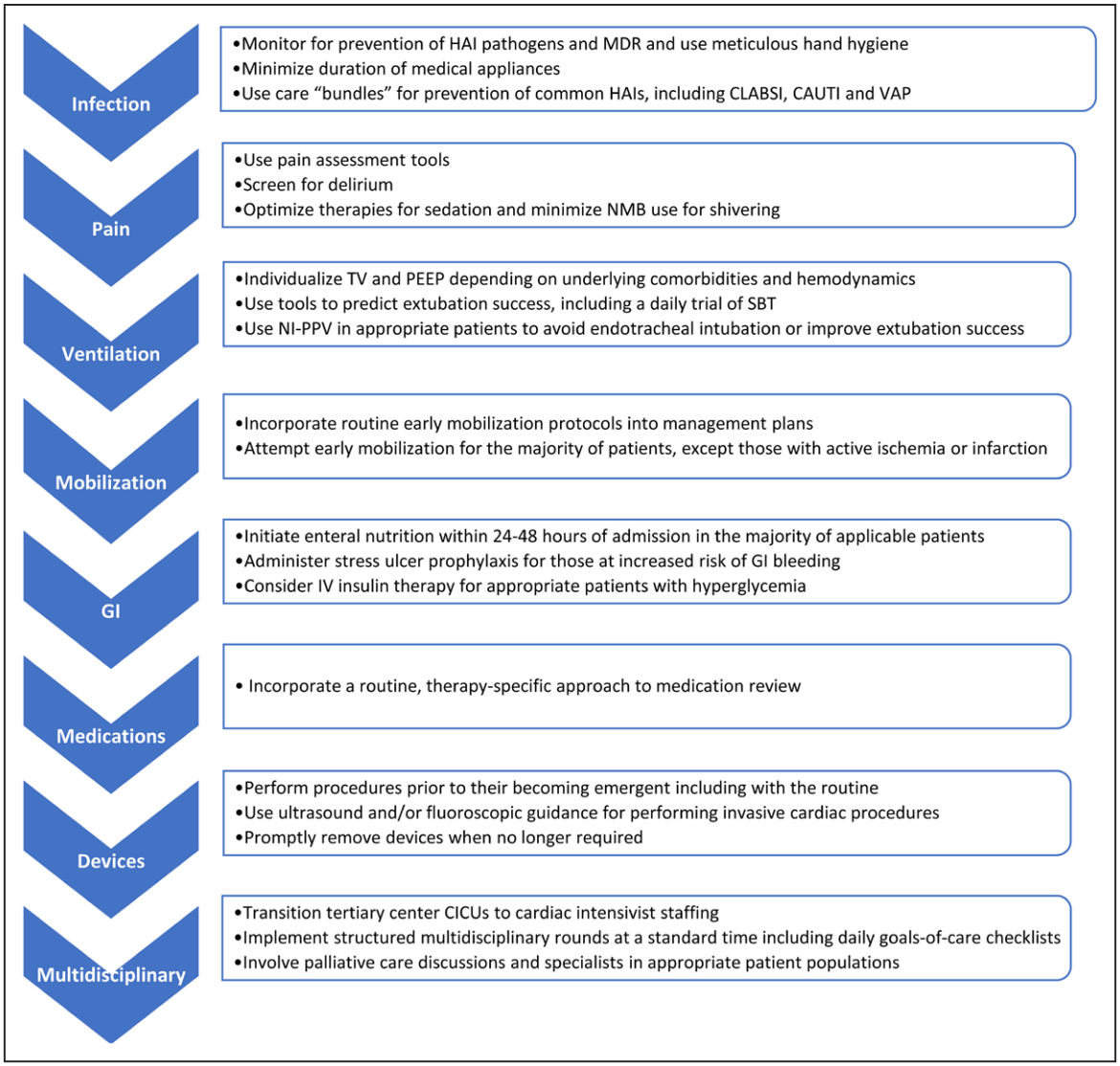

Figure 5. Daily bedside checklist to encourage best practices and to prevent complications for patients admitted to the cardiac intensive care unit (CICU). CAUTI indicates catheter-associated urinary tract infection; CLABSI, central line–associated bloodstream infection; GI, gastrointestinal; HAI, healthcare-associated infection; IV, intravenous; MDR, multidrug resistant; NI-PPV, noninvasive positive pressure ventilation; NMB, neuromuscular blocker; PEEP, positive end-expiratory pressure; SBT, spontaneous breathing trial; TV, tidal volume; and VAP, ventilator-associated pneumonia.

excellence for advanced care options not available at local sites.[136]

Within these specialized centers, coordinated care for patients with cardiogenic shock includes physicians with expertise in critical care, cardiology, cardiac intervention, cardiac surgery, and advanced heart failure, with assistance from other specialists as needed.[149] As the number and complexity of advanced care options increase, there is increasing recognition that dual-trained cardiologist/intensivists may be uniquely suited to navigate the cardiological and critical care issues, as well as the organizational, communication, and palliative aspects of the most critically ill patients. A single before-and-after study that evaluated the transition from an open ICU with general cardiologist staffing to unit-based staffing cardiac-intensivists reported reduced cardiac and noncardiac mortality with cardiac-intensivist staffing.[150]

Suggestions for CICU Practice

- We suggest implementing structured multidisciplinary rounds at a standard time and considering daily goals-of-care checklists.
- We suggest incorporating palliative care considerations into clinical decisions and involving specialists in palliative care in appropriately selected patient populations.
- We suggest that tertiary center CICUs transition to cardiac-intensivist staffing through new hires and succession planning.

SUMMARY

Critically ill patients are susceptible to a multitude of complications associated with increased morbidity, mortality, length of stay, and healthcare expenses.[1–3] The

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suggestions herein are based primarily on evidence generated from patients admitted to general medical or surgical ICUs. In the opinion of the writing group, this extrapolation of evidence is reasonable given that patients in the modern CICU appear to have significant overlap with respect to concomitant medical conditions and critical care–restricted therapies.[5] However, critically ill cardiac patients in CICUs are prone to complications unique to their underlying disease (ie, cardiogenic shock) or therapies (ie, antithrombotic regimens, MCS) that may be underrepresented in general ICU studies. Given the substantial heterogeneity in care of critically ill cardiac patients,[7] this document aims to provide standardized approaches to preventive care using the best available evidence. We suggest the use of a bedside checklist to inform best practices in the prevention of complications in this unique population (Figure 5). Future research and quality improvement efforts are required to better define the epidemiology of critical illness–related complications in the CICU patient population and to evaluate existing and novel therapies with rigorous multicenter clinical trials and large prospective registries.

ARTICLE INFORMATION

The American Heart Association makes every effort to avoid any actual or potential conflicts of interest that may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the writing panel. Specifically, all members of the writing group are required to complete and submit a Disclosure Questionnaire showing all such relationships that might be perceived as real or potential conflicts of interest.

This statement was approved by the American Heart Association Science Advisory and Coordinating Committee on June 10, 2020, and the American Heart Association Executive Committee on July 22, 2020. A copy of the document is available at https://professional.heart.org/statements by using either "Search for Guidelines & Statements" or the "Browse by Topic" area. To purchase additional reprints, call 215-356-2721 or email Meredith.Edelman@wolterskluwer.com.

Supplemental materials are available with this article at https://www.ahajournals.org/doi/suppl/10.1161/CIR.0000000000000909.

The American Heart Association requests that this document be cited as follows: Fordyce CB, Katz JN, Alviar CL, Arslanian-Engoren C, Bohula EA, Geller BJ, Hollenberg SM, Jentzer JC, Sims DB, Washam JB, van Diepen S; on behalf of the American Heart Association Council on Clinical Cardiology; Council on Arteriosclerosis, Thrombosis and Vascular Biology; Council on Cardiovascular and Stroke Nursing; Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation; and Stroke Council. Prevention of complications in the cardiac intensive care unit: a scientific statement from the American Heart Association. *Circulation*. 2020;142:e000–e000. doi: 10.1161/CIR.0000000000000909

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Disclosures

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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

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This table represents the relationships of reviewers that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all reviewers are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

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