Circulation

AHA SCIENTIFIC STATEMENT

Older Adults in the Cardiac Intensive Care Unit: Factoring Geriatric Syndromes in the Management, Prognosis, and Process of Care

A Scientific Statement From the American Heart Association

ABSTRACT: Longevity is increasing, and more adults are living to the stage of life when age-related biological factors determine a higher likelihood of cardiovascular disease in a distinctive context of concurrent geriatric conditions. Older adults with cardiovascular disease are frequently admitted to cardiac intensive care units (CICUs), where care is commensurate with high age-related cardiovascular disease risks but where the associated geriatric conditions (including multimorbidity, polypharmacy, cognitive decline and delirium, and frailty) may be inadvertently exacerbated and destabilized. The CICU environment of procedures, new medications, sensory overload, sleep deprivation, prolonged bed rest, malnourishment, and sleep is usually inherently disruptive to older patients regardless of the excellence of cardiovascular disease care. Given these fundamental and broad challenges of patient aging, CICU management priorities and associated decision-making are particularly complex and in need of enhancements. In this American Heart Association statement, we examine age-related risks and describe some of the distinctive dynamics pertinent to older adults and emerging opportunities to enhance CICU care. Relevant assessment tools are discussed, as well as the need for additional clinical research to best advance CICU care for the already dominating and still expanding population of older adults.

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Longevity is increasing, and more adults are living into old age, a stage of life when age-related biological and physiological mechanisms predispose individuals to cardiovascular disease (CVD) in a context of complexity related to their age.[1] Two-thirds of all patients with CVD are >60 years of age, and >85% of patients >85 years of age live with some form of CVD.[2] Although acute CVD is a leading cause of morbidity and mortality for adults of any age, older patients are at higher risk for adverse outcomes,[2,3] including mortality, rehospitalizations, diminished quality of life, and functional decline. Many older adults with acute CVD are often referred to cardiac intensive care units (CICUs) with the goal of achieving optimal care. However, although CICUs specialize in the care of acute CVD, they are not designed to address the broader context of health challenges in an older population.[4] Multimorbidity, polypharmacy, cognitive decline, and frailty are among the geriatric syndromes common in this population that can be exacerbated in the CICU. Typical CICU care entails medical procedures, bed rest, new medications, sedation, sensory overload (eg, excessive noise and light), disorientation, dietary shifts, sleep disruption, and toileting challenges that can deplete already limited coping reserves in older vulnerable adults.[5] Most clinical trials in acute CVD were performed in younger populations, and the generalizability of these findings to older patients is often confounded by concurrent geriatric syndromes.[6] This American Heart Association scientific statement describes the intersection of intrinsic CICU-related risks and geriatric vulnerabilities in older patients in the CICU and reviews the progress and limitations of current models and innovative models of CICU care designed to address the needs of the growing older adult population.

GERIATRIC SYNDROMES: COMMON HEALTHCARE CHALLENGES THAT DIFFERENTIATE OLDER FROM YOUNGER PATIENTS

Geriatric syndromes are commonly encountered clinical conditions in older adults that do not fit into discrete disease categories (Figure 1).[7] In recent years, there has been a strong emphasis by the American College of Cardiology, American Heart Association, American Geriatric Society, and National Institute on Aging to integrate geriatric syndromes into the cardiovascular care for older patients (Table 1).[8,9] However, integration has lagged, often because there are few interventions to address geriatric syndromes in the CICU and because they may be perceived as a lower priority than time-sensitive disease-oriented urgencies (Figure 2).

Delirium and Cognitive Dysfunction

Delirium is a state of an acute disturbance in awareness and attention that commonly arises during critical illness and contributes to increased hospital mortality, with estimates ranging between 17% and 33%.[10] Older patients with CVD, particularly those with baseline cognitive and sensory limitations, have high susceptibility to intensive care unit (ICU)–associated delirium (delirium estimate, 9%–44%).[11–13] In the CICU, delirium is additionally provoked by common circumstances of poor nutrition, dehydration, medications, anxiety, pain, sleep disruption, bright lights, bed rest, isolation, intravenous lines, and urinary catheters.[14,15] Although ICU research stands out for developing tools that better recognize delirium, there has been little progress in our collective ability to mitigate its sequelae.[16] However, adjustments in sedation protocols, procedures, and other components of CICU care have the potential to alleviate the incidence of delirium.

Key Points

- Delirium is common in CICUs because the stress of disease and the CICU environment are fundamentally destabilizing, particularly amid common age-related cognitive changes.
- The current CICU care paradigm may inadvertently provoke delirium.
- Tools to predict and identify delirium are available; however, new measures and therapies to prevent and treat delirium and related consequences are still required.

Frailty

Frailty is a clinical state in which there is increased vulnerability to stressors with a higher likelihood of functional decline, complications, and increased mortality from disease and therapeutic interventions.[17] Such vulnerability relates to diminished physiological reserves across multiple physiological systems.[18] Frailty is common among older adults admitted to the CICU, with an estimate as high as 63%.[19–21] It is a coderivative of pathophysiological inflammation, which can be exacerbated by CICU bed rest or acute disease. It should be noted that frailty syndrome exists as a continuum rather than as a dichotomous clinical condition and includes mild forms of frailty or prefrailty that are more prevalent than generally perceived.[22,23]

Frailty in older patients has a substantial impact during and after CICU admissions. Among older patients undergoing cardiac surgery, frail patients had increased risk for delirium and greater cognitive decline at the 1-month follow-up compared with patients who were not frail.[24] For those patients at greatest risk for dementia, frailty has been implicated in the rapid progression of cognitive decline,[25] particularly when exacerbated

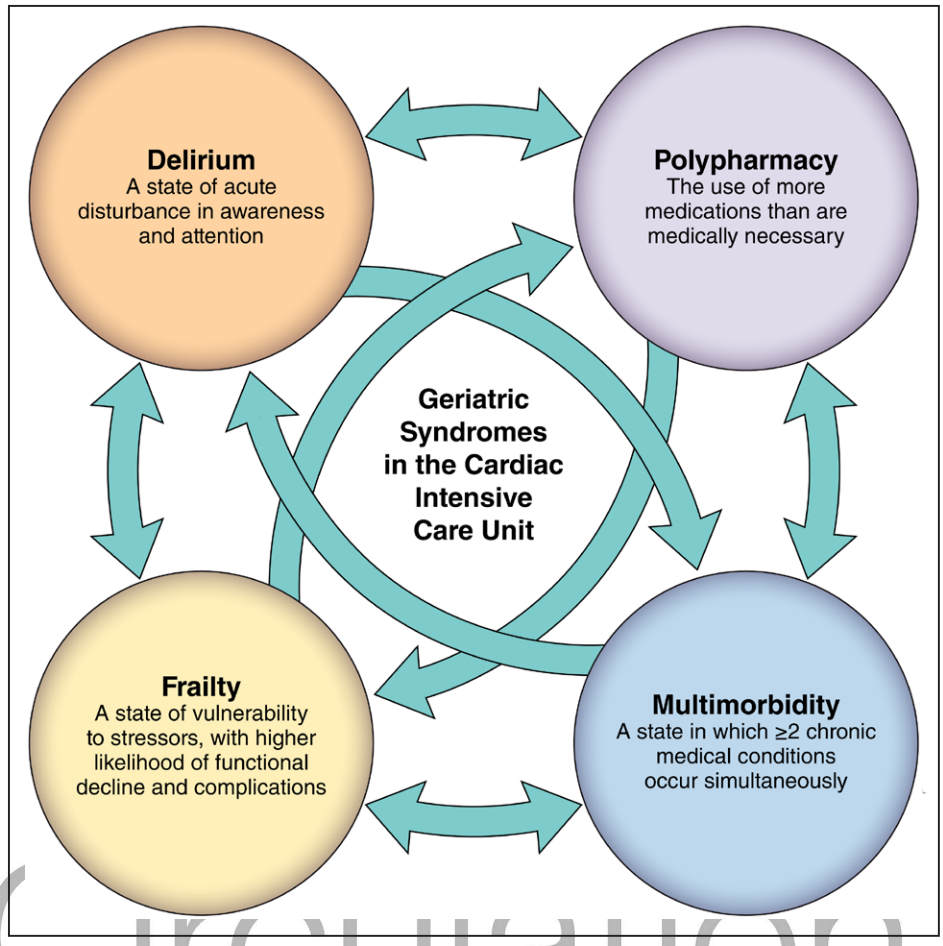

Figure 1. Common geriatric syndromes encountered in the cardiac intensive care unit.
The complex interplay between each geriatric syndrome and acute cardiovascular illness is illustrated.

by acute illness, delirium, and polypharmacy. Physical frailty often results in incident disability, physical impairment, falls, and loss of independence.[26]

Although interest in frailty has expanded among cardiology experts over the past 2 decades, the integration of frailty as part of CVD management has lagged, in part as a result of the lack of consensus on the best frailty metric.[17] Many well-known frailty indexes are premised predominantly on the biological underpinnings of frailty (eg, the Fried scale), and others are based on cumulative deficits that accrue as a result of frailty (the Rockwood frailty index).[27] Because both approaches predict poor outcomes, they do not necessarily identify the same individuals. Challenges of frailty assessment are additionally compounded by the circumstances of acute CVD instability, such that functionally oriented evaluations are inherently confounded by the clinical context.

Key Points

- Frailty is interlinked with CVD in older adults, and it is associated with high CVD risk and CVD therapies in the CICU. Worsening frailty and progressive impairments and disability are long-term risks that older patients have to endure. Research into better integration of frailty tools in the CICU is needed, and efforts to study prevention and even to reverse frailty should be among the goals of CICU care.
- Frail patients with CVD usually have poorer outcomes, with associated risks pertaining to baseline CVD, poor tolerance to medications and procedures, and physical (functional decline, falls, and cognitive impairments).

Multimorbidity

Multimorbidity is a state in which ≥2 chronic medical conditions occur simultaneously. The prevalence of multimorbidity rises significantly with age, such that ≈70% of all adults ≥75 years of age live with active coexisting multiple chronic conditions.[28] When older adults are admitted to the CICU with an acute CVD exacerbation, the CVD may have been provoked by excessive work demands stemming from non-CVD (eg, anemia triggering a myocardial infarction [MI]), or it may secondarily aggravate a non-CVD condition (eg, heart failure [HF]

Table 1. Overview of the Geriatric Syndromes Encountered in the CICU

Geriatric Syndrome	Definition and Prevalence	Prognosis and Clinical Implication
Delirium and cognitive impairment	Mild cognitive impairment→↓ cognitive function without loss of function; 10%/y–15%/y develop dementia Dementia→severe memory loss that interferes with daily life and loss of functional independence Dementia: 8.8%–11.6% in adults ≥65 y of age Delirium→disturbance in cognition, attention, and consciousness or perception with fluctuating course Delirium: as high as 14% in older adults living in the community; 17%–61% after major surgery; up to 83% at end of life.	Loss of independence Difficulty performing complex executive activities ↓↓ QOL ↓↓ Medication compliance ↑↑ Frailty ↑↑ Hospitalization ↑↑ Mortality
Frailty	A state of reduced physiological reserve in multiorgan systems ↑↑ Susceptibility to stressful event Tends to increase with CVD prevalence; can reach ≥50% of older adults with CVD	Worsens CVD prognosis and confounds management ↓↓ QOL Loss of independence ↑↑ Mortality ↑↑ Disability ↑ Falls ↑↑ Heart failure ↑↑↑ Hospitalization
Multimorbidity	Presence of ≥2 concomitant chronic disorders Prevalence: ≈2/3 of older adults Classification: cardiovascular and noncardiovascular conditions*	Influences CVD management ↓↓ QOL Loss of independence ↑↑ Mortality ↑↑ Disability ↑ Polypharmacy ↑ Falls ↑ Therapeutic burdens
Polypharmacy	Use of ≥5 medications ∝ to number of comorbidities ≈40% of older adults take ≥5 medications	↑ Iatrogenesis and medication errors ↑ Nursing home admissions Exacerbation of other medical condition (≈20%)

CICU indicates cardiac intensive care unit; CVD, cardiovascular disease; QOL, quality of life; ↑, increased; and ↓, decreased.

*Cardiovascular comorbidities include hypertension, dyslipidemia, ischemic heart disease, heart failure, stroke, valvular heart disease, and heart rhythm disorders. Noncardiovascular comorbidities include diabetes mellitus, osteoarthritis, obstructive lung disease, anemia, chronic kidney disease, dementia, depression, and geriatric syndromes.

management inducing renal failure), with myriad potential interactions and complications stemming from the crisscrossing diseases and treatments. Whereas guideline-based treatment for acute CVD is usually based on trials that enrolled younger populations with fewer comorbid conditions, guideline standards are less generalizable in scenarios in which older patients have 4 to 5 conditions, often with distinct medication regimens pertaining to each.[29] Treating multiple morbidities with complex regimens may inadvertently exacerbate

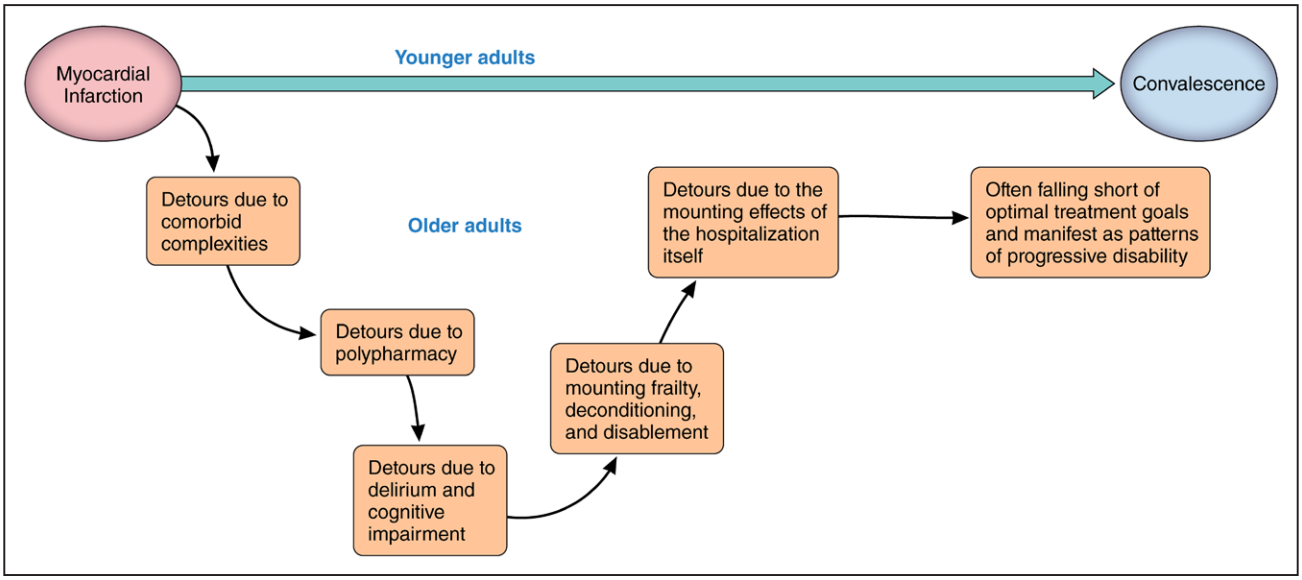

Figure 2. The influence of acute cardiovascular illness on convalescence in young and older patients.
Older patients frequently face detours resulting from geriatric syndromes before recovery, which falls short of the recovery encountered by younger patients.

Table 2. CICU-Associated Physiological Changes and Effect on Selected Cardiovascular Medication Pharmacokinetics

Pharmacokinetic Process	Physiological Change	Pharmacokinetic Effect	Drugs Affected
Distribution	Decreased total body mass; Increased proportion of body fat Decreased proportion of body water Decreased plasma albumin, disease-related Increase in α1-acid glycoprotein Altered relative tissue perfusion	Increased Vd of highly lipid-soluble drugs Decreased Vd of hydrophilic drugs Changed percent of free drug, Vd, and measured levels of bound drugs	β-Blockers, central α-agonists, digoxin, ACE inhibitors, disopyramide, warfarin, heparin, lidocaine
Metabolism	Reduced liver mass, liver blood flow Decreased CYP450 enzyme activity and hepatic metabolic capacity	Accumulation of hepatically metabolized drugs	Amiodarone, nitrates, lidocaine, diltiazem, warfarin, labetalol, verapamil, and mexiletine
Excretion	Reduced glomerular filtration, renal tubular function, and renal blood flow	Accumulation of renally cleared drugs	Digoxin, ACE inhibitors, antiarrhythmic drugs, sotalol, tirofiban, eptifibatide

ACE indicates angiotensin-converting enzyme; CICU, cardiac intensive care unit; CYP450, cytochrome P450; and Vd, volume of distribution.
Data derived from Font et al[13] and Falsini et al.[14]

delirium, polypharmacy, bed rest, and frailty and raise risks for poor outcomes. Although clinicians may rely on their own clinical judgment to best prioritize one disease over another in patients who are unstable, these strategies may vary according to experience and local practice patterns and can be especially difficult for clinicians who lack extensive experience and savvy.

Key Points

- Multimorbidity is common among older adults with CVD and often contributes to clinical decline.
- Efforts to understand the influence of multimorbidity on CICU care and novel therapeutic approaches tailored to address this geriatric syndrome are needed; disease-specific strategies of care can inadvertently set up many older adults to develop untoward effects of multimorbidity.

Polypharmacy

Polypharmacy entails the use of ≥5 medications, increasing the risk for inappropriate treatments, including medications that are not indicated, are not effective, or constitute therapeutic duplications.[30,31] Older adults admitted to the CICU take an average of 12 different prescriptions that include preadmission medications, new therapies for the primary acute pathophysiology, and management of destabilized comorbidities, anxiety, delirium, or sleep.[32]

As the number of prescription medications increases, so does the potential for adverse iatrogenic events, as well as drug-drug and drug-disease interactions. Goldberg et al[33] found that patients taking at least 2 prescription medications had a 13% risk of an adverse drug-drug interaction, which increased to 38% for 4 medications and to 82% with ≥7 medications. Medications for CVD may also provoke non-CVD instability (eg, lidocaine inducing delirium).

Between 50% and 85% of older adults are prescribed at least 1 potentially inappropriate medication during a hospital admission such as antipsychotics for hypoactive delirium. Similarly, medications such as opiates, benzodiazepines, and anticholinergic medications[34,35] are used to alleviate symptoms but with consequences of drug-induced delirium or excessive fatigue that delay or undercut recovery. Morandi et al[35] studied adults ≥60 years of age and showed that 50% of potentially inappropriate medications at hospital discharge were first prescribed in the CICU compared with only 20% on the hospital wards and 30% before admission.

With aging, multiple physiological changes affect both the pharmacokinetics and pharmacodynamics of many medications used in the acute cardiac care setting. Age-related decreases in renal function, reduced hepatic blood flow, increased body fat, and reduced muscle mass and total body water are often exaggerated in older individuals, which in turn affect the distribution, metabolism, and elimination of cardiovascular and noncardiovascular medications (Table 2).[36,37] In addition, age-related changes in end-organ responsiveness, along with the presence of cardiovascular comorbidities, can alter the pharmacodynamic response of many drugs.[36] Cardiovascular responses to catecholamines and carotid sinus baroreceptor sensitivity, for example, are diminished in older adults. Slowing of both sinus node activity and atrioventricular conduction in older patients leads to increased risk of bradycardia with β-adrenergic blockers and nondihydropyridine calcium channel blockers. As a result of increased arterial and ventricular stiffness, older patients may be preload sensitive, leading to a greater risk of hemodynamic lability from vasodilator therapies and diuretics and, conversely, increased risk of pulmonary edema with excessive volume resuscitation. Many cardiovascular pharmacotherapies, including procainamide, metoprolol, lidocaine, amiodarone, and digoxin,[10] also exacerbate neurocognitive impairments in older patients, with confusing effects that are often then compounded by non-CVD medications. In addition, acute noncardiac organ

dysfunction (eg, renal failure, hepatic failure, ileus) may affect the absorption, metabolism, or excretion of commonly used medications.

Key Points

- Polypharmacy disproportionately affects older patients in the CICU.
- Adverse events may be linked to age-related physiological changes in drug actions; organ dysfunction affecting drug absorption, metabolism, or excretion; and detrimental drug-drug and drug-disease interactions.
- The current CICU care paradigm may increase the likelihood of harm related to polypharmacy in older adults.

THE CICU AS A CATALYST OF INHERENT RISK FOR THE OLDER CVD PATIENT

Immobility, Bed Rest, and Consequences

Extended immobility and bed rest are detrimental to patients of all ages. Older critically ill patients tend to be affected disproportionately. Immobility and bed rest result in a substantial reduction in bone mineral density and accelerated sarcopenia, the accelerated loss of muscle mass, and frailty.[38] In medical patients in the CICU, bed rest has been linked to increased local and systemic inflammation, which predisposes to decreased muscle protein synthesis, increased urinary nitrogen excretion, and decreased muscle mass, especially in the lower extremities.[38] Poor nutrition and depression likely add to these patterns.[39,40] Within 2 weeks of immobilization, young healthy adults lose ≈5% to 9% of quadriceps muscle mass and 20% to 27% of quadriceps muscle strength,[41,42] and such atrophy is 3- to 6-fold greater in adults who are older.[43,44]

Bed rest also aggravates risks of pressure ulcers, especially amid chronic skin thinning of old age, the acute stresses of nutrition disruption, and the stress of disease. Stage I pressure injuries occurred in most patients in the CICU.[45] Stage I to II pressure injuries should be considered a warning sign for the development of more advanced pressure injuries in locations of pressure contact such as the sacrum, coccyx, and heels where fragile frames are most vulnerable.[45] Risks of thromboembolic events are also increased, especially in the context of high ambient inflammation.[46] Even cardiac function is weakened by bed rest, with decreased stroke volume, increased heart rate, and orthostatic intolerance within only 3 days of immobility.[47]

Combined with other geriatric risk factors (eg, polypharmacy and delirium), bed rest enhances unfamiliar sensory input, impaired feedback to position and voluntary movement, and altered awareness, cognition, sleep, and pain-related sensations.[47] After only 1 week of mechanical ventilation, one-third of critical care patients were reported to develop neuromuscular weakness, with increased duration of mechanical ventilation and ICU length of stay.[38] At the 1-year follow-up, survivors of critical illness reported poor physical function, poor exercise tolerance, and disability attributed to general ICU-related loss of muscle mass and weakening.[48] In medical ICU survivors, loss of physical capacity and quality of life often extended for years after the incident ICU treatment for acute respiratory distress syndrome.[49,50]

Key Point

- Immobility, bed rest, acquired muscle weakness, and pressure ulcers are consequences of CICU stay that often exacerbate or worsen preexisting geriatric syndromes in older patients with acute CVD.

Caloric Insufficiency

Decreased oral intake, poor appetite, or prolonged periods of invasive mechanical ventilation or critical illness result in malnutrition in patients treated in the ICU, especially because acute illnesses often manifest as hypercatabolic states with increased nutrient demands.[51] More than two-thirds of older patients in the ICU are at risk for malnutrition.[52] However, optimal caloric goals and accurate measurement of malnutrition in the ICU remain uncertain. Whereas a large intake of protein (1.2–1.5 g/kg per day) was associated with improved outcomes in an ICU study, another similar study showed no equivalent benefits.[53,54] There is no certainty that a fixed energy-to-nitrogen ratio can be applied effectively to all cardiac or critical care conditions.[51] However, in patients with a length of stay exceeding 4 days, high-protein diets and even early enteral feeding remain important considerations for older patients who have no absolute contraindications because they are innately predisposed to escalating mucosal and lean muscle atrophy, sarcopenia, and frailty. The total energy expenditure in older patients in the ICU cannot simply be predicted by equations and requires indirect calorimetry and dietitian expertise.[51,55]

Key Point

- Although optimal caloric intake for older patients with acute CVD remains an area of ongoing investigation, enteral nutrition can be considered to prevent mucosal atrophy and to preserve muscle, which in turn may prevent disuse atrophy.[56,57]

Other CICU Risks

Other factors also cluster in the CICU, further eroding overall stability in many older cardiac patients. High ambient noise, glaring light, sleep disruption, anxiety, and a

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context of many new medications all contribute to disruption. Although multiple therapies are often prioritized in the ICU on a 24/7 basis as a standard of care, they also induce physiological and psychological stress that may negatively influence stability in this vulnerable patient cohort.[58,59] In a very fundamental way, the paradigm of ICU care (ie, aggressive and fast-paced) contrasts with a geriatric paradigm of incremental and slower-paced care, and many older patients may be overwhelmed, tipping many patients toward delirium or depression.

Key Point

- The intensive acuity of a CICU environment and culture of care contrast with a prototypical geriatric approach. Many older patients may be overwhelmed in a CICU environment.

CHALLENGE OF ASSESSING GERIATRIC SYNDROMES AS PART OF ACUTE CARDIAC CARE

Convenient and reliable assessment tools to assess geriatric domains have been regarded as an important first step to better anticipating and responding to critical needs of older patients. However, application of these assessment tools is particularly challenging amid the acute medical instability in the CICU. Furthermore, application of geriatric conditions often remains undermined by ambiguities in their definition. For example, frailty stands out as a concept that seems intuitively relevant to subdividing care for older adults, but there is no gold standard for frailty on which to base a CICU tool. Amid a profusion of frailty literature, many frailty tools are being generated that do not correlate with one another, and it often seems that there is more of a competition than a unifying approach and method. Furthermore, even if frailty was definitively classified and a CICU tool refined, there is no certainty about therapeutic interventions that could substantively improve care. Still, better delineating frailty remains valuable as a tool to better inform decision-making and to help guide research and quality improvement initiatives to mitigate frailty risks over time. Opportunities to better integrate nutrition, rehabilitation, and palliative care are among the logical considerations for patients in the CICU who are very frail.

Inherent Methodological Challenges of Assessing Geriatric Syndromes in the CICU

Most tools to measure geriatric syndromes have been developed for nonacute settings. Even in these applications, the methodology is inherently challenging, with idiosyncratic differences from patient to patient and clinical circumstances. Assessments in the CICU are particularly difficult because they must rise above the limitations attributable to acute disease–triggered changes in physical and cognitive status that often distort assessments. Common pitfalls include variability in quality and quantity of available clinical data, the time and resource requirements of acquiring additional data, the ambiguous symptoms of older adults that may overlap multiple geriatric domains or even normal-for-age

Table 3. Common Methodological Challenges of Assessing Geriatric Syndromes in the CICU

Geriatric Syndrome	Assessment Tool	Challenges
Delirium and cognitive impairment	CAM-ICU Intensive Care Delirium Screening Checklist	Delirium is identified when it has already crossed a threshold of destabilization and prognostic decline. Prevention of delirium in an environment that remains inherently disposing to its incidence.
Frailty	Frail scale EFT	Suboptimal reliability of the "eyeball assessment" or details provided by family members because they are often influenced by the overall CICU volume on any given day or the experience of the CICU clinician. Novel biomarker[64–66] and imaging[67,68] metrics to measure frailty are potential tools but not yet validated during cardiac illness.
Multimorbidity	No universal tool Concordant and discordant subtypes in relation to CVD provide some utility	Choice of comorbidities often varies from 1 institution to another and may even vary from 1 patient to another. Thus, simple disease counts lack standardization and reliability. Amalgamating multiple deficits into a single score results in a loss of granularity that can reduce its sensitivity to change and dilute or conceal the effect of a potentially important individual deficit. Some discordant conditions relevant to CICU management (eg, prior falls or executive cognitive declines) are less well documented.
Polypharmacy	No universal tool	There is an unresolved challenge to balance relatively aggressive pharmacological therapies with approaches that also account for the susceptibilities associated with aging.

CAM-ICU indicates Confusion Assessment Method for the Intensive Care Unit; CICU, cardiac intensive care unit; CVD, cardiovascular disease; and EFT, Essential Frailty Toolset.

variations, and the obfuscating effects of acute critical illness, in which the combination of physical, mental, and iatrogenic stressors inflates the apparent severity of geriatric impairments and limits the ability of patients to productively participate in their evaluation.

Structured questionnaires might theoretically improve reliability for the assessment of comorbidity and frailty, but they are usually unworkable and impractical in an acute CICU setting. Furthermore, even if they are completed with the help of family members, issues of recall bias and ceiling effects are relevant, such that mild geriatric syndromes may be underestimated.[60] In recent years, using electronic medical records and gaining perspective from family members are on the rise.[61–63] Specific tools to detect delirium have been developed and endorsed by different societies of critical care medicine,[16] but they do not solve the issue of delirium, which is relatively embedded in broader issues of cognitive decline in older patients with CVD and in environmental circumstances of the CICU. Likewise, polypharmacy, frailty/sedentariness, and multimorbidity are entrenched aspects of the care paradigm, all of which highlight the need for innovative approaches to improve actionable assessments of age-related domains for the large and growing population of older patients in the CICU (Table 3).

PHYSIOLOGY OF CARDIOVASCULAR AGING

As adults grow into their older age, characteristic changes in the vascular structure, myocardium, valvular apparatuses, and conduction system become more apparent and have important implications in the development of CVD (Table 4).[70–72] Aging itself is a risk factor for cardiovascular pathophysiology that makes older patients vulnerable to acute cardiac illness. Aging is also associated with important changes in organs outside the cardiovascular system, including kidney function, pulmonary reserve, and hemostasis. Although a full review of the physiology of cardiovascular aging is outside the scope of this scientific statement on CICU care, comprehensive references are cited.[73,74]

MANAGEMENT OF ACUTE CVD IN THE CONTEXT OF GERIATRIC COMPLEXITIES

Myocardial Infarction

The incidence of MI increases with age. Whereas a wide variety of MI risk scores oriented to disease factors are applied during CICU management,[75–77] geriatric domains also affect prognosis and management but are less routinely considered. The majority of older adults with acute MI are initially admitted to the CICU. Among a sample of 324 729 Medicare beneficiaries with acute MI from 2010 to 2012, 65% were cared for in the CICU, and most of these CICU admissions were for patients ≥75 years of age (75–84 years, 35%; ≥85 years, 23%). Most had concomitant comorbid conditions, including many with high severity of illness (11.1% had shock, 18% had respiratory failure, and 13.6% had Angus organ failure score of >2 of maximum score of 6).[78]

On a relatively more fundamental level, multimorbidity can provoke MI pathophysiology. Whereas type 1 MIs (ie, ST-segment–elevation MI [STEMI]) correspond to plaque erosion or rupture, type 2 MIs (ie, non-STEMI) result from supply-demand mismatch and are more common in older adults who typically have less physiological reserves to meet acute demands. Cardiovascular reserves in older adults progressively diminish amid age-related myocardial and vascular stiffening, chronotropic incompetence, and other physiological changes of age and chronic disease.[79,80] Type 2 MIs more commonly occur when tachyarrhythmias, hypertension, and other conditions induce physiological demands that exceed limited supply capacities or undercut oxygen delivery (eg, bradycardia, shock, anemia). Notably, in circumstances when a noncardiac condition is the cause of the MI, the risk of in-hospital mortality is increased 5-fold (adjusted odds ratio [OR], 5.0 [95% CI, 3.3–7.7]).[81]

Thus, on a primary level, multimorbidity adds to MI risk. In a study of MI in association with HF, peripheral vascular disease, and hypertension, researchers showed a 2.4-fold (95% CI, 2.3–2.5) higher mortality associated with the cumulative comorbid conditions.[82] Furthermore, multimorbidity contributed to a pattern of progressive instability. In 1 study, atrial fibrillation, HF, or cardiogenic shock was more likely to occur in the context of preexistent multimorbidity, with compounding risks and consequences.[83] Frailty similarly predisposes to MI and worsens prognosis once MIs occur.[20] Mortality risks jump 3-fold (3.07 [95% CI, 1.35–6.98]) in patients with MI who are frail.[84]

Pharmacological complexities often extend from multimorbidity in older adults with MIs. Most patients end up receiving complex regimens for their cardiac disease and for multiple diseases that remain active concurrently. Unintended and detrimental interactions may result. β-Blockers for MIs, for example, may exacerbate chronic obstructive lung disease. Antiplatelet therapies may exacerbate gastrointestinal bleeds in patients prone to peptic ulcer disease. Furthermore, medications for sedation, sleep, agitation, and depression are commonly added as part of CICU management and may compound polypharmacological risks. The irony and clinical difficulty in these examples are that many medications are prescribed intentionally by CICU specialists to counteract the agitating aspects of CICU environment.

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Table 4. Age-Associated Physiological Changes in the Cardiovascular System

System	Physiologic Changes	Clinical Implications
Vascular system	Arterial wall ↑↑ Arterial wall media thickness ↑↑↑ IMT ↑ Fraying of elastic fibers ↑↑ Collagen content ↓↓↓ Arterial dispensability ↑↑↑ Arterial stiffness* Endothelial function ↓ Vasodilation ↓ NO production ↑ Angiotensin II signaling Oxidative stress and inflammation ↑ NADPH oxidase ↑ Uncoupled NO synthase ↑ Xanthine oxidase ↓ Antioxidant capacity	↑↑ Isolated systolic hypertension ↑ Diastolic pressure until sixth decade ↓ Diastolic pressure after sixth decade ↑ Pulse pressure† ↑ Cardiac workload ↓ Renal function ↑ Vascular encephalopathy ↑ Aortofemoral PWV ↑ Atherosclerotic disease
Cardiac structure and function	LV composition and mass ↓↓ Number of myocyte ↑↑ Myocyte hypertrophy ↑ Deposition of collagen, fibrous tissue, amyloid, and lipofuscin within connective tissue LV wall thickness, cavity size, and shape ↑↑ Myocardial thickness ↑↑ Concentric LVH ↑ Interventricular wall thickness ↑ Spherical LV shape Left-sided heart valves ↑ Calcium deposition and collagen infiltration Myxomatous degeneration Fixation of valvular leaflets LV function ↓ Early diastolic peak filling ↑ LV filling facilitated by atrial contraction ↑ Late LV filling	LV ↑ LV stiffness and fibrosis ↑↑ LV dysfunction and heart failure ↑↑ LV systolic and diastolic volumes ↑↑↑ Ratio of LV mass to volume ↑↑ Susceptibility to HFpEF‡ ↑↑ Susceptibility to myocardial ischemia Left atrium ↑ Atrial size ↑ Susceptibility to AF Left-sided heart valves ↑ Aortic sclerosis and stenosis ↑ Mitral annular calcification ↑ Mitral and aortic regurgitation
Cardiovascular physiology	Response to exercise ↓VO_2max per 1 kg weight at peak exercise Inability to increase LVEDP during exercise ↑↑ Sarcopenia ↓↓ Body weight ↑↑ Muscle fiber atrophy (fast twitch) ↑ Intramuscular fat	↑ Pulmonary hypertension ↓ Myocardial contractility ↓↓↓ Functional independence ↓↓↓ Quality of life ↓↓ Muscle function

AF indicates atrial fibrillation; HFpEF, heart failure with preserved ejection fraction; IMT, intima-media thickness; LV, left ventricle; LVEDP, left ventricular end diastolic pressure; LVH, left ventricular hypertrophy; NO, nitric oxide; PWV, pulse wave velocity; VO_2max, maximum oxygen consumptions; ↑, increased; and ↓, decreased.

*Mainly large and medium-sized arteries.

†Pulse pressure is defined as the difference between systolic and diastolic blood pressures, which is a potent predictor of cardiovascular events.

‡Exacerbated by stress-induced tachycardia

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MI also increases risks for escalating cognitive impairment and delirium, particularly among many who have suffered subtle declines in executive cognition but who until their acute event were relatively functional in the community. In the acute setting of MI, cognition often worsens in the context of reduced cardiac output and abnormal vascular coupling (ie, contributing to abnormal cerebral perfusion),[85] especially in the context of multimorbidity (compounding effects of disease and medications) and frailty (diminished mobility and self-confidence), and adverse CICU environmental circumstances (noise, sleeplessness, isolation) add to the vulnerabilities for acute delirium.

In multiple studies, researchers found that the use of reperfusion for STEMI within 12 hours of symptom onset declined significantly with age.[86] In other reports, older patients with STEMI who were revascularized achieved outcomes that were relatively superior.[86–88] Although 93% of patients <75 years of age received reperfusion therapy, only 89% of those 75 to 84 years of age and only 79% of patients ≥85 years of age (P<0.001) received similar therapy. Primary percutaneous coronary intervention (PCI) is generally considered the optimal reperfusion strategy because it minimizes bleeding risks, but it is used in only 30% of patients with STEMI who are ≥85 years of age.[89] Frail patients with MI are particularly unlikely to undergo coronary

angiography (71% versus 94%) or percutaneous revascularization (54% versus 77%) compared with those who are not frail.[20,21]

The potential utility of primary PCI for MI is evident in the AMIS (Acute MI in Switzerland) registry. Among 13 662 patients ≥70 years of age studied in the AMIS registry, the use of any PCI in older patients increased from 44% to 70% from 2001 and 2012 at a time when the Charlson comorbidity score among those receiving PCI also increased. In a comparison of PCI- and medically treated patients, in-hospital mortality was similar in each cohort, but long-term assessments after PCI showed safety and long-term benefit. Overall invasive management of revascularization with PCI seems excellent despite higher risks associated with age, comorbidity, and frailty.[91,92] Invasive care seems both safe and effective, especially when steps to optimize bleeding reduction (eg, radial access) and delirium reduction (eg, avoiding anticholinergics) are taken.[93]

Although type 2 MIs are attributable to supply-demand mismatch that may have little to do with coronary heart disease, the After Eighty trial concluded that an initial invasive strategy was superior to a conservative strategy for patients with type 2 MI who were ≥80 years of age for the reduction of composite outcome of death, MI, stroke, and urgent revascularization.[93] However, this was a composite end point driven largely by the reduction in need for urgent revascularization (hazard ratio, 0.19 [95% CI, 0.07–0.52]; *P*=0.001) and MI (hazard ratio, 0.52 [95% CI, 0.35–0.76]; *P*=0.001) with no difference in stroke or death. The efficacy of the invasive strategy was diluted with increasing age, and differences in the primary outcome did not translate into better quality of life at 1 year.[94] The study population of 457 was only 11% of the 4187 who were screened for enrollment, raising questions about the generalizability of the results. Regardless, investigators in the After Eighty trial suggested that an initial invasive approach for non-STEMI in older adults was safe and reduced the need for future revascularization. Among invasively managed older patients, the invasive approach can also target culprit vessel–only PCI or multivessel PCI. Culprit vessel–only PCI is by far the most common approach, with only 1 in 10 patients with STEMI and 1 in 4 patients with non-STEMI with multivessel disease undergoing multivessel PCI.[95] Multivessel PCI lowers the risk of symptom-driven unplanned coronary revascularization, but angina and quality of life are similar.[96]

However, despite conceptual advantages for aggressive acute care for older adults, enthusiasm is tempered by the high risks attributable to age-related intricacies. Among 10 992 propensity score–matched nursing home residents after an acute MI (mean age, 84 years), β-blocker use was associated with a higher rate of recurrent hospitalization for hypotension (OR, 1.20 [95% CI, 1.03–1.39]) or breathlessness (OR, 1.10 [95% CI, 1.01–1.20]).[97] Nonetheless, pertinent details on dosing, comorbidity, concomitant medications, surveillance, and other intricacies were relevant but were not clarified in analyses. A comprehensive approach seems indicated, such that any single therapy must be structured within a context that accounts for broader risk challenges.

A particularly challenging subgroup of patients with MI are those presenting with shock and multivessel disease, in whom multivessel or culprit vessel–only PCI may have different safety and efficacy considerations. Among patients presenting with shock and MI, age >75 years (OR, 2.4 [95% CI, 1.3–4.4]), multivessel disease, renal failure, and anemia are strong independent predictors of mortality. Primary PCI lowered mortality in MI complicated by shock by 50% (OR, 0.5 [95% CI, 0.2–0.9]) and improved survival over the last 10 years.[98] The CULPRIT-SHOCK (Culprit Lesion Only PCI Versus Multi-Vessel PCI in Cardiogenic Shock) trial compared culprit vessel–only PCI with multivessel PCI among patients with MI and shock. Culprit vessel–only PCI lowered the risk of a composite of death resulting from any cause or severe renal failure leading to renal replacement therapy compared with multivessel PCI at 30 days.[99] At 1 year, rehospitalization and repeat revascularization were more frequent with a culprit vessel–only approach.[100] Thus, improved 30-day survival and renal preservation favor the culprit vessel–only PCI approach among frail and vulnerable older patients with MI and shock.

Age is a risk factor for bleeding resulting from fragility of vessels and excess dosing of adjustable antithrombotic agents. The vulnerability to bleeding is particularly relevant for older adults with MI who are frail and those who struggle with multimorbid and polypharmacological complexities. Major bleeding is more likely among patients with MI with acuity factors such as presenting after cardiac arrest or with HF or cardiogenic shock, STEMI, higher heart rate, and lower reserves such as anemia, lower body weight, and lower creatinine clearance.[101]

Acute Decompensated HF

The incidence of HF increases with age; many older adults present with acute decompensation and are admitted to CICUs. HF with reduced ejection fraction is common in older adults; it often represents an end-stage manifestation of coronary artery disease, chronic hypertension, chronic valvular heart disease (VHD), or persistent atrial fibrillation. These processes also promote HF with preserved ejection fraction. HF is a complex syndrome that may be fundamentally related to multimorbidity, being driven by chronic inflammation in the setting of diabetes mellitus, hypertension, obesity, or chronic kidney disease.[102] Regardless of ejection

fraction, patients with HF are typically older adults with a high prevalence of geriatric syndromes at baseline, with cognitive impairment in 43%,[103] frailty in up to 75%, and polypharmacy in 74%.[104,105] Patients' clinical characteristics make them vulnerable to poorer clinical outcomes and functional decline during and after management in a CICU.

Overall, approximately one-third of patients in the CICU carry a primary or comorbid diagnosis of HF.[106] Valley et al[78] retrospectively analyzed all acute care hospitalizations in Medicare fee-for-service beneficiaries from 2010 to 2012. They found that 24.7% of patients ≥65 years of age hospitalized for HF were admitted to the CICU. Older patients had greater severity of illness and a higher risk of death than those admitted to the general ward (18.2% versus 9.1% 30-day mortality; $P<0.001$), as well as higher costs of care. However, the 30-day mortality in CICU admissions was similar to that in patients in the general ward after adjustment for patient and hospital characteristics and the instrumental variable of geographical distance from a high-CICU-use hospital (12.1% versus 11.0%; $P=0.14$).[78] Remarkably, after the probability of CICU admission unrelated to illness severity was accounted for, CICU care did not appear to reduce short-term mortality in older Medicare recipients with acute HF. Findings were consistent with a nationwide Canadian cohort study[107] and a recent French cluster randomized trial in which systematic triage of older adults (some with HF) to CICU care increased use but did not affect 6-month mortality rates.[108]

Management of both HF with reduced ejection fraction and HF with preserved ejection fraction is commonly complicated by age-related challenges: multimorbidity, frailty, polypharmacy, and cognitive decline. Multimorbidity was directly linked to HF with reduced ejection fraction and HF with preserved ejection fraction pathophysiology and can provoke cardiac instability. Frailty was closely associated with HF because inflammation pathophysiology underlies each.[109] Polypharmacy has been an important component of the evidence-based management of HF, which predictably entails complex regimens for concurrent cardiac and noncardiac instability.[110,111] Delirium and worsening cognition were similarly expected amid diminished cardiac output, labile hemodynamics, vasoconstriction, and the addition of new medications.

Using a simplified Comprehensive Geriatric Assessment (CGA) score, which assessed active geriatric syndromes plus a history of cognitive impairment, Rodriguez-Pascual et al[112] found an independent, graded relationship with in-hospital and 2-year postdischarge mortality in older inpatients with HF. Other geriatric conditions commonly present in hospitalized patients with advanced HF increased the risk of functional decline, rehospitalization, and death by 2- to 4-fold.[104,113,114] It is not clear how often CICU healthcare providers assess or intervene in common geriatric conditions, and few data specific to critically ill older patients with HF are available.

Commonly used treatment and monitoring strategies for HF in the CICU such as indwelling urinary catheters, pulmonary artery catheters, and temporary mechanical support devices triple the odds of developing delirium[10] and create a high likelihood of prolonged immobility. Even healthy older persons have measurable declines in muscle strength and physical functioning after 10 days of bed rest,[115] and these effects are likely exacerbated in already frail patients with HF. Compounding this issue are the poor nutritional status of many patients with advanced HF[113] and the hypercatabolic state of critical illness. Yet, up to 25% of patients did not receive nutritional support during a medical ICU stay, and many received less than half of their estimated caloric needs.[116] Incomplete nutritional support could be related to poor appetite/oral intake or withholding for hemodynamic instability, but it can also be iatrogenic (underordering by clinicians, prolonged cessation of enteral feeding for procedures). From a medication standpoint, HF drugs may be appropriately or inappropriately held during severe decompensation. However, important medications for chronic illness are often unintentionally discontinued permanently during an CICU admission.[32] Medication discontinuation may be particularly important to consider as the proportion of patients in the CICU with primary noncardiovascular diagnoses increases.[106]

Management of HF in the CICU may be driven by specific underlying causes, and the principles described in the acute MI and acute VHD sections are applicable (see Myocardial Infarction and Acute VHD sections). Progressive cardiac failure and shock, whatever the reason, may rapidly result in an irreversible cascade of organ dysfunction leading to death. Intravenous inotropes and vasopressor agents may sometimes provide sufficient support, but in-hospital mortality rises sharply when ≥2 agents are required. Goals of care should be quickly established, with consideration of how geriatric syndromes and preexisting functional impairment may affect the futility of or recovery from temporary (eg, intra-aortic balloon pump, axial or centrifugal continuous-flow device) or durable (eg, left ventricular assist device) mechanical circulatory support.

Acute VHD

The incidence of VHD rises rapidly as adults reach very old age, overlapping with biological determinants of multimorbidity, frailty, and other geriatric complexities.[117,118] Whereas older age previously impeded rationale for surgical interventions,[119,120] the inception of transcatheter valve technologies reduced restrictions on certain valvular procedures. According to data from the Society of Thoracic Surgeons/American College of

Cardiology TVT (Transcatheter Valve Therapy) registry, the majority of patients currently treated with transcatheter therapies were octogenarians with multiple comorbidities (average Society of Thoracic Surgeons Predicted Risk of Mortality score >6%) and prominent frailty (as assessed by inability to walk or to walk only with a slow gait speed in >60% of cases).[121,122] However, catheter-based treatment options were not effective in many acute circumstances, and even when improvements in catheter and surgery options enabled complex and frail patients to endure an acute intervention, it remains unclear whether patients recovered sufficiently to enjoy a satisfying and valued quality of life thereafter.

Patients presenting with acute VHD can be classified into 2 categories: patients with acute valve lesions and patients with chronic severe VHD who become acutely decompensated as a result of rapid left ventricular dysfunction or significant volume overload. Both conditions are more common among older adults and are likely to result in CICU management if patients quickly deteriorate amid limited cardiovascular reserves.

The most common causes of acute valve lesions include endocarditis, chordal or papillary muscle rupture, aortic dissection, acute myocardial ischemia, prosthetic valve dysfunction, and iatrogenic injury.[123] Diagnostic and treatment algorithms for acute VHD are well established and available in clinical practice guidelines,[124,125] and management in older adults is based on the same guideline-directed medical therapies and care principles used in younger adults.

Acute severe aortic regurgitation has a mortality of 100% if not surgically corrected. An intra-aortic balloon pump is contraindicated, and there is limited experience with other percutaneous left ventricular assist devices.[123] Compromised elderly patients are at extremely high risk for endocarditis (native or prosthetic) or aortic dissection surgery. Notably, transcatheter therapies have not been tested in acute aortic regurgitation and are contraindicated in patients with active endocarditis.[126]

Acute decompensation among patients with aortic stenosis usually occurs as a result of comorbid conditions such as myocardial ischemia, renal insufficiency, or respiratory disease. Patients are usually refractory to medical therapy and have prohibitive surgical risk, and the decision to perform balloon aortic valvuloplasty or transcatheter aortic valve replacement (TAVR) is not straightforward. Emergency TAVR is feasible in selected patients, but it is associated with a higher risk of stroke and vascular complications.[127] TAVR was futile in patients with high Society of Thoracic Surgeons Predicted Risk of Mortality score (>15%),[128] and a strategy of balloon aortic valvuloplasty is sometimes attempted as a bridge to subsequent TAVR or surgical aortic valve replacement when patients are more stable. Patients who experience recovery may have improved myocardial function, mobility, and nutrition to the point that they become better candidates for elective TAVR or surgical aortic valve replacement. Lack of recovery may predict futility and is a reason to avoid further procedures.[86]

Initial treatment of acute mitral regurgitation often begins with medical therapy and stabilizing procedures such as percutaneous left ventricular assist devices, intra-aortic balloon pumps, microaxial flow pumps (Impella), or left atrium–to–aorta extracorporeal pumps (TandemHeart). Acute functional mitral regurgitation may improve with treatment of the underlying condition (ie, acute myocardial ischemia, stress cardiomyopathy), whereas organic mitral regurgitation was associated with a mortality of nearly 80% if not surgically treated.[129]

Mitral valve surgery in patients with MI was associated with high in-hospital mortality of up to 42%. Transcatheter edge-to-edge mitral valve repair with the MitraClip device is an appealing treatment, and successful cases have been reported.[130]

Geriatric risks are relevant for older patients struggling with acute destabilization, but they are particularly challenging to assess and address in the turbulent circumstances. The most commonly used cardiac surgery risk scores such as the Society of Thoracic Surgeons Predicted Risk of Mortality score and EuroSCORE may be less accurate in older patients, especially because they do not capture relevant factors related to frailty and disability.[131,132] To increase accuracy and to capture the risk of future morbidity and mortality in older patients, researchers used data from the PARTNER (Placement of Aortic Transcatheter Valve) trial and CoreValve trial to develop risk models of geriatric factors,[133,134] but newer risk models do not address issues pertaining to acute management.

The presence of concurrent coronary heart disease in older patients with VHD is common and prognostically important. Severe coronary heart disease has been reported in ≈30% to 60% of patients referred for valve surgery and up to 75% of patients referred for TAVR.[135,136] Based on observational data, current guidelines recommend revascularization for patients with severe coronary heart disease undergoing surgical or transcatheter valve intervention.[124,125] Nonetheless, combined valve and bypass surgery is associated with less favorable outcomes. The benefit of PCI before, during, or after TAVR is controversial, and PCI is usually reserved for the treatment of severe proximal lesions.[137] Dual antiplatelet therapy after PCI in elderly patients increases bleeding risk and may complicate management when anticoagulation is required for other reasons such as atrial fibrillation or venous thromboembolism. Added complexities of other diseases and medications are likely but have not been well delineated for standardized decisions.

Assessment of futility becomes a critical part of the decision-making process for acute VHD. Futility is de-

fined by a lack of medical efficacy or an inability to produce the intended clinical result, to prolong survival, or to provide meaningful survival according to patient individual values.[138] Valve interventions are generally considered futile when life expectancy is <1 year despite procedural success or when there is low chance (<25%) of improvement in symptoms, quality of life, and life expectancy.[139] Futility is fundamentally linked to multimorbidity, frailty, and other geriatric complexities and is often raised as an important consideration in the decision-making process for patients with VHD.

Many clinicians promote the importance of palliative care as an important alternative to procedures for acute VHD.[140] However, in counterpoint, opportunities for enhanced rehabilitation[141] exist as an interrelated consideration in the evaluation of futility and estimation of what is and is not ultimately remediable.[39]

Acute Aortic Syndrome

Data for aortic syndromes as an aging phenomenon are limited. The incidence of acute aortic dissection peaks in the sixth and seventh decades, and the prevalence is expected to increase with aging of the population. Medical principles of management in older adults are similar to those for the general population, with reliance on transfer to a surgical center and intravenous agents to control blood pressure to a systolic goal of 100 to 120 mm Hg and a heart rate of 50 to 60 bpm. Most patients are transferred to CICUs. However, in contrast to younger patients, routine emergency care is relatively more disruptive and destabilizing in those who are older.[142]

The IRAD (International Registry of Acute Aortic Dissection) was established for the purpose of enrolling patients to assess the presentation, management, and outcomes of acute aortic dissection. More than one-third of the patients in IRAD were >70 years of age. Older adults in IRAD were less likely to present with typical symptoms, which may render the diagnosis even more challenging. When suspected, the diagnosis of aortic dissection was best confirmed by a contrast-enhanced computed tomography angiography of the aorta, but older patients often have severely compromised renal function, which prevents computed tomography assessments. A transesophageal echocardiogram is usually used as an alternative.

Acute type A aortic dissection is a time-sensitive surgical emergency. Although age by itself is not a contraindication to surgery, it remains an independent predictor of mortality, especially in an emergency setting.[143–145] Notably, half of the patients between 80 and 90 years of age enrolled in IRAD were turned down for surgery because of high operative risk.[146] Nonetheless, mortality with conservative management far exceeds surgical mortality, and in newer reports, acceptable mortality was found for octogenarians who had corrective surgery, especially in the absence of shock.[147–149]

In a series of 686 patients with type A dissection with a mean age of 78±12 years between 2005 and 2015 at the Cleveland Clinic, only 53 subjects were considered inoperable. Overall, 18 were considered at prohibitive risk because of the presence of dementia, advanced malignancy, severe malperfusion, and severe stroke, and 35 were turned down because of procedural risks.[150] Although the inoperable rate was significantly lower than in IRAD, patients who were turned down had a high rate of CICU complications (eg, acute renal failure, 23%; cardiac arrest, 19%; mechanical ventilation, 15%; and new neurological deficit, 13%), and >47% were referred to hospice care.[150]

Even among those older adults who undergo surgical intervention for a dissecting aortic aneurysm and survive, long-term neurological and other complications may still detrimentally affect long-term mortality and quality of life. In a population of 310 patients with an average age of 67.5±11.9 years from Japan undergoing surgery for type A aortic dissection, 106 (34%) were considered frail (average age of the frail group, 76.2±7.9 years).[151] Those authors used a 7-component score with variables including age >70 years, body mass index <18.5 kg/m^2, creatinine >1.2 mg/dL, hemoglobin <12 g/dL for women and <13 g/dL for men, albumin <3.5 g/dL, history of stroke, and a psoas muscle index; they defined frailty as the presence of ≥3 parameters. Frailty measured with these parameters was not associated with short-term outcomes but was significantly associated with diminished 5-year survival (85.1% versus 57.7%; P=0.0001). To minimize long-term morbidity and mortality risks among older adults in general and especially in those who are frail, the extent of surgery for type A aortic dissection is usually targeted with emphasis on resection of the primary tear and replacement of the ascending aorta. Long-term management should also ideally include steps to moderate frailty and related risks for disability and clinical decline.

The general principles of the management of type B aortic dissection include blood pressure control, pain management, and close surveillance for common hazards (eg, rupture, early false lumen expansion, and evidence of malperfusion). Older age is also an independent factor for mortality in type B aortic dissection. The mortality rates in IRAD are greater in patients >70 years of age regardless of medical management (<70 years of age, 14.2%; ≥70 years of age, 32.2%; P=0.01) or the use of endovascular intervention (<70 years of age, 10%; ≥70 years of age, 30.1%; P=0.01) or open surgery (<70 years of age, 17.2%; ≥70 years of age, 34.2%; P=0.02).[152] The presence of malperfusion caused by branch vessel involvement, evidence of periaortic hematoma, and hemodynamic instability all portend increased mortality in patients >70 years of

age. The absence of these 3 factors identifies a low-risk patient with a mortality rate of 1.3 %.[153]

Mortality rates for emergent open surgery in the older adults with types A and B dissection are very high.[154,155] The advancement of endovascular interventions will likely help some of this acute mortality risk, but current clinical trial data on efficacy in older populations are lacking. In the absence of endovascular options in unselected octogenarians, medical treatment appears to be a reasonable alternative to be considered over open surgery, but issues of comorbidity, frailty, polypharmacy, and cognitive decline still can play a decisive and detrimental role, no matter what treatment is used. In some instances, patients with type A dissection and inoperable surgical risk have an identified entry tear that can potentially be sealed by an endovascular device and dramatically moderates morbidity and mortality. The design and development of devices in this area is warranted.

Pulmonary Embolism

The incidence of thromboembolic disease increases with age.[156] Multimorbidity is a leading contributor to risk, with cancer and renal failure among the diseases that commonly lead to pulmonary embolism (PE).[157] Increased age-related sedentariness and hospitalizations add to these patterns. Geriatric patients with PE are also at a greater risk for adverse events than their younger counterparts. Death, recurrent embolic episodes, and bleeding associated with antithrombotic strategies are seen more frequently in older individuals hospitalized with a PE.[158]

Age is also an independent determinant of delays in clinical presentation to a healthcare setting, adding to overall risk.[159,160] Older adults are more likely to present with atypical features; that is, they are less likely to describe classic shortness of breath or pleuritic chest pain and more likely to seek medical attention after a syncopal event.[159]

From a diagnostic perspective, the strength of testing strategies for acute PE may be attenuated in the geriatric population. Although the specificity of a D-dimer value is variable with advancing age,[161] recent literature suggests that age-adjusted D-dimer values may maintain the specificity seen in younger adults. However, ventilation-perfusion scans are less likely to be diagnostic for older patients because of the increased prevalence of baseline cardiopulmonary disorders and radiographic abnormalities.[162] Ventilation-perfusion scans are also less likely to be diagnostic for older patients because of baseline cardiopulmonary conditions and radiographic abnormalities.[162] Computed tomographic imaging may be more challenging as a result of the greater risk of contrast-associated nephropathy in older patients with chronic kidney disease.

Even when PE is diagnosed, therapeutic challenges persist. Inappropriate dosing of systemic anticoagulation is common amid concomitant renal dysfunction. Bleeding is more common after the administration of thrombolytic agents, and evidence pertaining to the application of novel anticoagulants is limited.[46] The risks of these medications must be balanced with their known benefits, particularly in unstable individuals.

Key Points

- The management of the most common acute CVD is often complicated in older patients. Although many conventional precepts of management remain applicable, geriatric syndromes are also relevant and require complementary consideration in relation to assessment and management.
- More studies are needed to integrate conventional CICU clinical standards to geriatric complexities.

DECISION-MAKING, GOALS OF CARE, AND ETHICAL CONSIDERATIONS IN THE CICU

Acute CVD is organized primarily in relation to guidelines-based principles. Whereas clinical judgment is called on in relation to aging domains, such integration remains unstandardized and inconsistent. The intrinsic association of acute CVD with geriatric complexities implies a need for tailored approaches that more fundamentally and clearly interconnect non-CVD geriatric domains.[163,164] It remains unclear whether the decisions to withhold therapy are well informed and whether sufficient efforts were considered that might minimize harms potentially associated with their implementation. Given the examples of acute MI, HF, VHD, aortic syndromes, and PE, disease-specific approaches appear important, but so too is flexibility to respond to the contextual variability implicit with comorbidities, frailty, delirium, polypharmacy, and other geriatric intricacies.

Standards to assess and address geriatric risks are aligned with excellent CICU care. Principles of early mobilization,[165–167] minimized sedation,[168–172] deprescription of unnecessary medications,[173–175] facilitation of orientation[176–179] (including prioritization of hearing aids, glasses, and other sensory-enhancing appliances),[179] nutritional support,[180] and physical and occupational therapy[181–183] are all consistent with putative benefit. Table 5 lists a spectrum of management principles for optimized CICU care. Patient-centered care that was cocreated by patients, physicians, registered nurses, and other healthcare providers and delivered with a team-based approach led to an increase in general self-efficacy for knowledge about the current acute MI condition and goals for recovery,[184] especially in patients without postsecondary education.[185] In a systematic review of 11 controlled studies (of patients with

Table 5. Acute Cardiovascular Care Management Principles

Care Principles	Value	Considerations
Early mobilization	Reduced intensive care weakness Improved functional recovery during hospitalization Improved walking distance before hospital discharge Reduced intensive care and hospital length of stay May not improve survival or other long-term outcomes, mental health (anxiety or depression), or cognitive-related delirium-free days	Requires a positive team culture involving leadership, providers (written orders), planning (readiness screening algorithm), and team/interdisciplinary communication Requires the use of safety equipment for employees (patient lifts) and patients (reclining chairs or chair-beds, analgesia before mobilization, sedation management, family engagement) for mobilization Pain, low Glasgow Coma Scale score, agitation, physiological instability Lines, drains, tubes, and recent medical procedures may increase safety risks. Most research reports were completed in patients treated in medical, respiratory, neurological, or surgical ICUs, not CICUs; thus, the value-to-risk profile in older adult patients with acute CVD requires further study.
Sedation minimization	When the amount of time awake and alert is increased or when patients are lightly sedated without benzodiazepines, ventilator-free time and delirium-free time are increased.[168] Sedation-free protocol may increase days without mechanical ventilation in critically ill patients, but agitated delirium was higher in the intervention group.[169] Use of low-dose dexmedetomidine created light to moderate sedation and was not inferior to propofol and midazolam use in mechanically ventilated patients.[170] Use of low-dose dexmedetomidine may decrease the occurrence of delirium in older adults and improve patients' ability to communicate pain.[170,171] However, in a report of mixed critically ill patients, it increased hypertension and bradycardia,[171] and in a report of noncardiac surgical patients treated in the ICU, the usual care group had more tachycardia than patients receiving dexmedetomidine and there was no difference in hypotension between groups.[172]	Use dexmedetomidine initially at a rate of 0.5 $\mu g \cdot kg^{-1} \cdot h^{-1}$; titrate to rates between 0 and 1.5 $\mu g \cdot kg^{-1} \cdot h^{-1}$ to achieve sedation goals.[170] Can use the Richmond Agitation-Sedation Scale or the Sedation-Agitation Scale to assess agitation associated with sedation liberation and to determine the need for sedation. Most research reports were completed in patients treated in non-CICUs; thus, the value-to-risk profile in older adults with acute CVDs requires further study.
Deprescribing of medications	In comparisons of usual care and deprescribing groups, those in the deprescribing group had less deterioration in general satisfaction and functional and cognitive status. Sleep quality, appetite, and sphincter control were improved or stable, and complications were reduced.[173] Health improvements occurred within 3 mo of deprescribing.[173]	Among older adults, deprescribing was more common among patients with dementia, incontinence, and functional decline.[173] Complex drug regimens need to be monitored and challenged by (1) creating awareness of options or tailored therapy, (2) engaging patients in discussion about options, (3) exploring patient preferences for deprescribing options, and (4) monitoring and re-evaluating decisions.[174] Include pharmacists in multidisciplinary team rounds with the goal of tailoring drug therapies, including deprescribing medications that are no longer indicated or of benefit; they should also provide patient education and complete medication reconciliation. In a systematic review of 89 articles on deprescribing, no reports focused on patients with acute cardiovascular conditions, although many older adults could have had cardiovascular comorbidities. Definitions of deprescribing varied and included dose reduction, removal of inappropriate medications, and optimal prescribing.[175] Research is needed in older adults with acute cardiovascular conditions to ensure that deprescribing of drugs enhances quality of care and clinical outcomes and reduces potential harm.

(Continued)

Table 5. Continued

Care Principles	Value	Considerations
Reorientation	In 2 studies of verbal reorientation along with environmental, acoustic, and visual stimulation, delirium occurrence in the ICU was lower.[176,177] When a multipanel discussed delirium incidence and prevention in older adults, reorientation was considered a weak nonpharmacological recommendation (because of low quality of evidence and uncertainty of value) but was included as a part of a multicomponent intervention.[178] In 1 report, families were adherent in providing orientation or memory clues each day and cognitive stimulation via discussions of family life and reminiscing.	Reorientation devices that enhance environmental, acoustic, and visual cognitive stimulation include a large clock, calendar, radio, television, and telephone. Reorientation measure include: using the first name, giving information about the unit and the hospital name, sharing the patient's unit length of stay and illness progression, and wearing of own clothes. Once per shift, ask the following: Who (are you)? What (happened)? When (did it happen)? Where (are you/we)? Why (did it happen)? How (did it happen)? Research into dynamic communication aimed at enhancing patient reorientation is needed in coronary care because most research involves medical ICU environments.
Use of home hearing aids, glasses, and other appliances	In a feasibility study, sensory checks (vision and hearing via glasses and hearing aids) and memory clues via family photographs were acceptable activities conducted by family members of hospitalized patients in the medical/surgical ICU as measures to reduce delirium.[179]	Sensory checks and memory clues by family members were acceptable activities; however, outcomes have not been assessed to determine the size of the effect, if any. More research is needed, including placement of memory cues and amount of time spent using home appliances during a typical day in the ICU.
Nutrition support	Although the rate of malnutrition is not well known among patients in CICUs, ICU malnutrition can affect respiratory drive and the immune system and is associated with hospital mortality.[180]	Consulting an ICU dietician and implementing a feeding guideline can promote progressive parenteral nutrition. Because oral energy intake may be low, early introduction of feeding by parenteral nutrition may promote better energy balance. ICU severity scores, energy delivery, cumulated energy balance, and feeding route information can assist in optimizing a nutrition plan.[180]
Physical and occupational therapy in preparation for cardiac rehabilitation	In patients who received exercise and mobilization via physical and occupational therapy during a critical illness, independent functional status was higher at hospital discharge, and patients had shorter duration of delirium and more ventilator-free days compared with control participants.[181] In a Cochrane review, there was insufficient evidence on the effect of early mobilization of critically ill adults in the ICU.[182]	The use physical and occupational therapy to enhance early mobilization has not been studied in the CICU environment. The association of early mobilization and adherence, ordering practices for cardiac rehabilitation, and patient adherence to cardiac rehabilitation program services is not known. The presence of a mobility protocol may prompt delivery of activity among high-acuity patients.[183]

CICU indicates cardiac intensive care unit; CVD, cardiovascular disease; and ICU, intensive care unit.

multiple conditions), the intervention was successful in 8.[186] Surprisingly, after acute MI, there were no differences between groups in rehospitalization or mortality,[184] suggesting a need for further study and refinement.

End-of-Life and Shared Decision-Making

Shared decision-making can assist patients and families in understanding goals of care. In a policy statement by the American College of Critical Care Medicine and American Thoracic Society, experts highlighted that shared decision-making was a critical component of patient-centered care and delineated 6 recommendations: (1) Decision making is a collaborative process that allows for patients' values, goals, and preferences and best scientific evidence; (2) clinicians should engage in shared decision-making to define overall goals of care, including withdrawal of life-prolonging therapies; (3) clinicians should ensure that they routinely exchange information and deliberate; (4) ethical decision-making models should be integrated (including surrogate-directed and clinician-directed variations); (5) clinicians should be trained in communication skills; and (6) research on outcomes of decision-making strategies is needed.[187]

However, implementation of shared decisions in the CICU is logistically complicated. Although decision aids have been advanced in relation to implantable cardioverter-defibrillation use[188,189] and anticoagulation in atrial fibrillation,[190] tools for the broader spectrum of acute disease challenges in the CICU are still necessary. In particular, shared decision-making implementation is confounded by the acuity of care amid phases of care in which outcomes can seem ambiguous and life decisions are especially difficult.

Notably, in a study of emergency room management, decisions aids were feasible and increased knowledge and engagement in making decisions for patients with chest pain and low risk for acute coronary syndrome. Decisions on management in an observation unit versus outpatient care services were enhanced.[191,192] It remains

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necessary to advance skill sets and strategies to achieve similar benefit in the CICU.

Palliative care provides an opportunity for patient-centered management with direct communication, shared decision-making on available treatment options, advanced care planning, and attention to physical, emotional, spiritual, and psychological distress.[193] It also provides methods to integrate family and broader care dynamics amid acute cardiac illness. Although improving patient-reported outcomes is critical, patients and family usually benefit from discussions of realistic expectations near the end of life. A major goal of end-of-life assessment is alleviating the burden of distressing symptoms, including pain, dyspnea, and anxiety. Access to requisite medications and equipment, hospice care, and support for family members is essential for CICU care and planning in older adults with end-stage disease processes.[193]

Principles of palliative care and end-of-life assessment were recently highlighted by an American Heart Association policy statement with an overarching aim of improving quality of life of cardiac patients by preventing and alleviating suffering and relieving distress among their family members.[193] Despite such endorsement, palliative care and end-of-life assessment are vastly underused in the CICU.[194,195] One report shows that among 1368 CICU admissions, only 6.2% of patients received end-of-life discussions.[196] Similarly, in patients with advanced HF, resuscitation preferences, implantable cardioverter-defibrillator deactivation, and a preference for quality of life over extended survival were rarely discussed.[197] However, in instances when goals of care were considered, there were higher rates of comfort care, greater constraints on the escalation of care, and increased withdrawal of life-sustaining treatments.[196] Future care planning, care preferences, palliative care management, and resolution of conflict related to the future seem to be critical components of shared decision-making priorities, particularly in relation to the broader context of geriatric complexities.[198]

Key Points

- Shared decision-making, end-of-life care, and palliative care services complement care in the CICU and enhance management in older patients with acute CVD.
- The proven utility of palliative care suggests that it remains significantly underused in the CICU.

EVOLVING CONCEPTS IN CICU: TRANSITIONAL CARE, MULTIDISCIPLINARY TEAMS, AND POST-CICU

This document has focused largely on the widespread complexities associated with older patients in the CICU and the need for more research. However, related innovations have already begun to evolve, highlighting the advances in CICU quality care. Novel approaches to transitional care, multidisciplinary teams, and prevention all have probable value in progressing clinical excellence.

Transitional care programs are collectively defined as interventions designed to improve clinical outcomes, including hospitalization, quality of life, and survival, among populations transitioning from one care setting to another. Incorporating a transitional care approach as part of CICU care entails innovative patient-centered services and enhancements to provider-patient and provider-provider communications and collaborations. Multifaceted transitional care services for adults with HF have proliferated and have led to reduced all-cause hospitalization.[199–201]

A systematic review of evidence evaluating the influence of transitional services on improving quality of care for patients with stroke or MI showed that there was low to moderate strength of evidence to support hospital-initiated interventions and services to improve some outcomes. For example, 1 study showed that the total number of hospitalized days was reduced but without benefit in quality of care, functional recovery, or death after stroke or MI.[202] Overall, significant variability remains in studies of transitional care in respect to outcomes, timing of measurement, and interventions themselves, such that their utility is still hard to quantify and compare.[202] Transitional care programs for older adults after acute cardiac care may have particular value amid the vulnerabilities associated with geriatric syndromes.

Multimodal approaches to older patients in the CICU seem intuitively logical given the concurrent challenges of disease and aging and the associated physical, nutritional, emotional, and social dimensions of care. However, comprehensive multimodal interventions to address comorbidity, frailty, delirium, and polypharmacy in older adults have largely been limited to outpatient populations.[203] Still, focus on geriatric principles pertaining to older patients in the CICU has begun to evolve.[204] Innovative multidisciplinary models of care are being organized that entail collaborative teams from cardiovascular, critical care, and geriatric societies; healthcare systems; and local leadership.[204] Team approaches can help expand the range of therapeutic focus and priority, such that CVD management is better integrated with efforts to preserve function, to moderate frailty and other geriatric syndromes, and to integrate transitional care.[204]

Preventive CICU protocols have demonstrated utility in moderate geriatric syndromes in older patients. Early critical care mobilization protocols stand out for their utility in reducing hospitalization complications and shortening lengths of stay.[16,205,206] Early enteral nu-

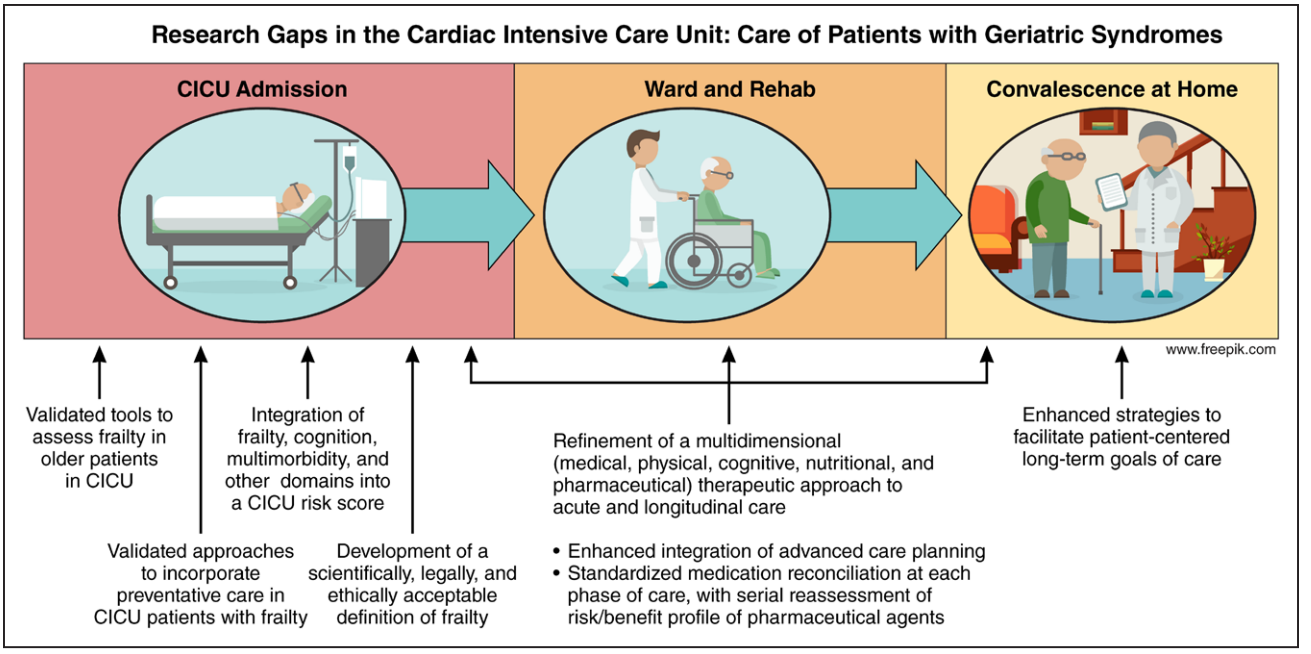

Figure 3. **Research gaps in the cardiac intensive care unit (CICU) to enhance convalescence for older patients with geriatric syndromes.**

trition within 48 hours of admission in patients unable to maintain volitional intake remains controversial but has been demonstrated to reduce mortality, infection complications, and lengths of stay.[207]

Pharmaceutical prevention includes medication reconciliation, adoption of critical care sedation protocols, and selection of critical care sedation regimens that are less likely to cause delirium.[208] Although the role of a clinical pharmacist as part of a multispecialty care team has evolved, it has not been extensively studied in relation to CICU management.[209,210] Nonetheless, the value of a specialized cardiac pharmacist as part of care for older adults has been established in other contexts[211] and remains a compelling consideration for the CICU. Finally, care bundles (grouping of individual evidence-based practices) for central line insertion and ventilator-associated pneumonia prevention reduced infectious complications, which were associated with significant morbidity and mortality.[212,213]

Although assessment of frailty in the CICU is still not standardized, studies indicate that frailty assessment helps in shared decision-making, often leading to plans to minimize therapeutic risks and to consider quality of life over survival goals.[214,215] Examples include the selection of management choices that ensure relatively more rapid mobilization or reduced risks of bleeding. In addition, when frailty is identified, providers can potentially initiate multidisciplinary transition planning between care units or facilities that includes physical rehabilitation, occupational therapy, psycho-social, and nutritional support.

Key Points

- Although geriatric syndromes are often still overlooked as elemental aspects of CICU care, a growing body of insight suggests the utility of approaches that factor these risks into assessment and management to achieve improved outcomes.
- Transitional team, multimodal approaches, and preventive care can all be integrated with CICU precepts to enhance care for an aging population.

CLINICAL KNOWLEDGE GAPS AND RESEARCH OPPORTUNITIES

Many advancements in the care of older patients in the CICU have been achieved as part of quality improvement as geriatric precepts largely extend principles of best care regardless of patient age. Essentially, geriatric excellence emphasizes the premise of a holistic rather than disease-specific approach, which becomes relevant to any patient with elements of complexity that affect the management of any single disease. Patients who are frail may benefit most from approaches that are substantially different from those used in patients who are robust. Developing tools to assess these (often shifting dynamically in the CICU) characteristics is logical but often elusive. CGA constitutes a rigorous ideal established by geriatricians to understand all facets of each older adult. However, even in the nonacute hospital setting, CGA remains technically difficult to achieve, and its cost-efficacy remains uncertain.[216] The goal to extend this into standard CICU care remains compelling in concept but still in need of refinement and testing. Opportunities to use electronic medical records to facilitate comprehensive assessments, including geriatric domains, are already being studied in relation to frailty and multimorbidity.[217] Some centers have incorporated an index type of CGA measure into

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their electronic medical system to evaluate multimorbidity and frailty in older adults anticipating a procedure or surgery (ie, acute stressor).[218]

Recognizing geriatric domains may help CICU clinicians refine therapeutic strategies most likely to succeed. Technical details (eg, medication choices, doses, procedural methods) can be individually tailored to the full range of each patient's risks. Perhaps even more important, better assessment of geriatric domains may help better inform fundamental management directions, better ensuring that each patient's personal healthcare goals are recognized and prioritized amid their overall health circumstances. Beyond conventional standards of survival and length of stay, care can better be oriented toward quality of life, functional independence, self-efficacy, or other metrics that are meaningful to each patient (Figure 3).[219]

Better discernment of futility is a related area of care-enriching opportunity. Consensus definitions of futility in critical care include "interventions [that] should generally be considered inappropriate when there is no reasonable expectation that the patient will improve sufficiently to survive outside the acute care setting"[220] and "advanced curative/life-prolonging treatments that would almost certainly result in a quality of life that the patient has previously stated that he/she would not want."[221]

It seems sensible that CICU clinicians individualize treatment plans by incorporating multidisciplinary assessment and management strategies and patients' wishes, with awareness of the impact of multimorbidity, polypharmacy, cognitive limitation, and frailty, to guide care that is grounded in evidence-based feasibility, that is, acknowledging and quantifying a threshold of futility. Refining scientifically, ethically, and legally accepted futility seems an essential process to help reduce clinical uncertainly, costs, and squandered resources in end-of-life CICU care.[222–224]

As illustrated in this work, evidence for many aspects of the diagnosis and treatment of geriatric syndromes in the CICU is lacking. Although some innovative ICU care paradigms presented in this work were derived from research in general critically ill patients, research in patients in the CICU remains a gap that is important to fill. Nevertheless, we remain confident this this American Heart Association position statement identifies key risks related to predominant patient aging that extend to the CICU, raises awareness among cardiovascular providers of the complexity of care for older patients, and highlights important gaps in CICU care that merit further attention and investigation.

Key Points

- Strategies to achieve a holistic approach to each patient, that is, consistent with a CGA, remain an important goal to improve the care of older patients in the CICU.
- Frailty and cognitive decline, both chronic and dynamic phenomena (ie, exacerbated by acute illness), are significant modifiers to therapeutic efficacy. Recognizing geriatric syndromes is a key first step in choosing care that is most likely to succeed and that is most consistent with each patient's personal goals of care.
- Frailty, cognitive decline, and other geriatric domains often accelerate in older adults as an effect of the CICU environment and thereby compound vulnerability to CICU-acquired weakness, weight loss, delirium, and other detrimental manifestations. Indolent and acute exacerbations of geriatric syndromes in older patients in the CICU highlight the need for studying dynamic CICU care models.

CONCLUSIONS

Geriatric syndromes are common in older patients admitted to the CICU, and they often complicate the care for this already vulnerable population. In the care of an older patient with an acute CVD, a thoughtful approach to critical care management requires consideration for geriatric syndromes including, but not limited to, delirium, frailty, multimorbidity, and polypharmacy. As the US older adult population expands, the influence of these geriatric syndromes on the healthcare system will be magnified in the years come. As part of the American Heart Association initiative to improve cardiac care for older adult populations, we highlight areas where future investigations are needed to integrate geriatric syndromes into the overall CICU models of care.

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.

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*Modest.

†Significant.

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