Resuscitation of the Critically Ill Older Adult

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KEYWORDS

• Geriatrics • Shock • Resuscitation • Critical care • Goals of care

KEY POINTS

- Adults older than 65 years represent an increasing proportion of the population that is at increased risk of critical illness and death.
- Due to the physiologic changes of aging, the presentation of critical illness varies in the older population, as do the goal metrics of successful resuscitation.
- Although age does not limit clinical outcomes, comorbidities and poor functional status can. The most appropriate management provides the care that best incorporates prognosis with the patient's personal goals of care.

EPIDEMIOLOGY OF CRITICAL ILLNESS IN OLDER ADULTS

There is no agreement as to when old age begins, but the widely accepted age for the purposes of research and epidemiologic tracking is 65 years. It is predicted that 83.7 million Americans, one-fifth of the population, will be older than 65 in 2050.[1] The mortality and complexity of disease in this cohort is significant. Intensive care unit (ICU) utilization in the United States by patients 65 and older has increased in the past 20 years,[2] with an increasing proportion of admissions in patients 85 and older.[3] In Europe, the overall median age of ICU patients is already 65 years[4] and even older in surgical ICUs.[5] The number of medical comorbidities increases from an average 2.6 (SD 2.09) in the 65-year to 84-year age range to 3.62 (SD 2.30) in the 85 years and older cohort.[6] Comorbidities combined with age, sex, and type of admission are predictive of mortality,[7] and mortality increases with age in the ICU independent of illness severity and treatment intensity.[8]

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PHYSIOLOGY OF AGING AND CRITICAL ILLNESS

The natural changes that occur during the normal aging process put the older patient at risk for higher severity of illness due to a decreased ability to tolerate and respond to said illness. The exact mechanism for these changes and the reasons for the variation in age at which different patients experience them is unclear, but leading theories involve an interplay between genetic predisposition and free radical damage.[9]

Cardiovascular

The cardiovascular system undergoes a great deal of change that, unsurprisingly, has downstream effects in the response to critical illness as well as to the resuscitation delivered. Advancing age is an inherent risk factor for the development of cardiovascular disease; arteriosclerosis contributes to hypertension and secondary decreases in left ventricular compliance due to hypertrophy.[10] Conduction abnormalities increase as myocytes decrease and undergo fibrotic changes, and the heart becomes less responsive to sympathetic drive, becoming inherently less able to mount compensatory heart rate increases to improve cardiac output. Myocyte hypertrophy and fibrosis lead to impaired relaxation and diastolic dysfunction, so although the older heart is more reliant on preload, it is also less tolerant of overaggressive fluid resuscitation and is at higher risk for development of pulmonary edema.[10,11] Older patients have higher incidences of cardiac arrhythmia[12] and coronary artery disease,[13] placing them at risk for secondary decompensation even if their primary disease process is not cardiac in nature, and contributing to an overall decreased cardiac reserve.

Pulmonary

The aging body seems primed for respiratory failure, with various components of the pulmonary system degrading with age. Increasing kyphosis causes decreased chest wall compliance while respiratory muscles weaken. Changes to the lung parenchyma (loss of elasticity, alveolar dilatation, and small airway collapse) decrease surface area for gas exchange and complete the trifecta responsible for decreased maximal inspiratory and expiratory flows, decreased oxygen tension, and ventilation-perfusion mismatch.[14] Older adults have decreased chemoreceptor sensitivity to hypoxia and hypercapnia, and with their decreased reserve can decompensate rapidly.[14] Immunosenescence and decreased mucociliary clearance, often accompanied by impaired swallowing, increases risk and incidence of aspiration in this population.[15]

Renal

The renal system also undergoes age-related decline, with the onset and extent of said decline depending on genetics, gender, and medical comorbidity.[16] With aging, there is a decrease in glomerular filtration rate (GFR) due loss of functioning nephrons secondary to glomerular sclerosis, as well as alterations in glomerular pressure and renal blood flow due to increased vascular resistance. This decrease in GFR may not be readily evident, as a decreased overall muscle mass results in a lower serum creatinine. Decreased renal tubular function and decreased renin-angiotensin-aldosterone system activity lead to a decreased ability to regulate fluid, electrolytes, and acid-base balance. Older, relatively healthy individuals may, despite decreases in GFR, still have relatively intact renal function at baseline, but functional reserve is markedly reduced[16] and results of dysfunction in critical illness can be life-limiting.

Hepatic, Endocrine, Neurologic, Immunologic

Other organ systems undergo changes with advancing age as well. Although the cellular function of the liver is generally well-preserved, there is decreased activity of the cytochrome P450 system and decreased drug clearance.[17,18] Due to decreased hepatic flow, the liver has a lower tolerance for ischemia,[17] such as that experienced in shock. There is an overall decreased basal metabolic rate, and older patients are at higher risk for development of hypothyroidism and diabetes.[19] The brain's autoregulation of cerebral perfusion is diminished,[20] leading to increased sensitivity to acute changes and extremes of blood pressure. There is inherent neurocognitive degeneration with aging,[21] and older patients have a higher risk of delirium, which is associated with increased mortality.[22] The immunosenescence of aging leads to an impaired antibody and cellular response to infections, and poor nutrition status worsens immune function and otherwise hinders the aging body's ability to recuperate from severe illness, leading to increased mortality.[23]

MANAGEMENT OF SHOCK IN THE OLDER ADULT

Shock Assessment

Frank hypotension is an obvious clue to the presence of a potential shock state, but critical illness can be present without marked vital sign abnormalities. Clinicians should be aware of alterations in potential presenting features of critical illness and decreased perfusion in older adult so as not to miss occult shock or impending decompensation (**Table 1**).

Initial Steps

Although critically ill patients usually receive simultaneous interventions, initial steps should follow the standard "C-A-B" algorithm, actively working to stabilize hypotensive patients to optimize hemodynamics and avoid peri-intubation cardiac arrest should an emergent intubation be indicated. Large-bore intravenous (IV) access is ideal for resuscitation, both for rapidity of fluid infusion and for peripheral vasopressor use. Multiple IVs are usually necessary for infusion of all the medications and therapies needed.

A full set of laboratory tests should be obtained, including venous blood gas, lactate, complete blood count with differential, comprehensive metabolic panel, prothrombin time/international normalized ratio, and partial thromboplastin time, with consideration for troponin if an electrocardiogram indicates potential ischemia and fibrinogen if there is concern for disseminated intravascular coagulation. Blood cultures should be obtained for patients with unexplained hypotension or with apparent infection. Further investigation for the source of possible infection should be pursued via urinalysis and urine culture (via catheterized sample if the patient is altered) as well as chest radiograph and sputum culture if the patient is able to provide one. An endotracheal aspirate should be obtained in patients who are intubated. Additional diagnostics depend on patient presentation and etiology of shock. Emergency physicians should have a low threshold to obtain computed tomography imaging of the brain in patients with depressed mental status and should pursue more expansive imaging of additional organ systems if the patient is unable to provide history or react to examination.

Point-of-Care Ultrasound

In undifferentiated shock, bedside ultrasound or POCUS (point-of-care ultrasound) is a key diagnostic tool. Evaluation of the heart identifies ventricular dysfunction, right

Table 1
Shock assessment in the critically ill older adult

	Vital Signs		Physical Examination
Heart rate	• Compensatory tachycardia may be absent due to meds, heart disease	Mental status	• Altered mentation an underrecognized sign of shock[31,32] • CAM-ICU improves delirium detection in the ED[32](100% Sn, 98% Sp)
Blood pressure	• Chronic hypertension[24] may obscure relative hypotension • Shock index is a good early indicator of acuity[25] and mortality risk[26,27]	Capillary refill time	• Detects hypoperfusion (>3 s) and can guide resuscitation • Predicts mortality[33,34]
Respiratory rate	• Baseline respiratory rate higher than average adult[28] • Further tachypnea indicative of illness[28]	Skin	• Higher skin mottling scores a strong predictor of mortality[35,36] • Improvement in mottling with resuscitation linked to better outcomes[35,36]
Temperature	• Lower baseline temperatures[29] • 1/3 of patients afebrile despite infection[30]	Urine output	• Decrease in urine output a sign of renal injury and marker of mortality[37]

Abbreviations: CAM-ICU, confusion assessment method for the intensive care unit; ED, emergency department; Sn, sensitivity; Sp, specificity.

heart strain from massive pulmonary embolism (PE), valvular insufficiency, tamponade, or hypovolemia. The remainder of the RUSH (Rapid Ultrasound in Shock and Hypotension) examination can identify tension pneumothorax, intraperitoneal hemorrhage, or aortic pathology.[38]

Ultrasound can and should be used to guide resuscitation.[39] Although there are many methods to assess volume responsiveness, one of the best validated is stroke volume and cardiac output calculated via the velocity time integral (VTI) of the left ventricular outflow tract (LVOT). The accuracy of LVOT-VTI has been confirmed by correlation with invasive monitoring by pulmonary artery catheter intermittent thermodilution,[40] and measurements of pre-passive and post-passive leg raise LVOT-VTI is a quick, validated way to assess for IV fluid responsiveness.[41] In cases in which the LVOT cannot be visualized, carotid VTI measurement for carotid blood flow has also been validated.[42] It should be noted that there are currently no studies specifically investigating resuscitative ultrasound in older patients, and most studies have an average age range from 53 to 69 years.[41]

Dynamic assessments should be chosen over static assessments of volume responsiveness. Volume tolerance assessed via pulse wave Doppler of the hepatic,[43] portal,[44] or internal jugular[45] circulation is possible but interpretability depends on the experience of the sonographer.

Hypovolemic Shock

Older patients with hypovolemic shock should be resuscitated with crystalloid or blood products as appropriate. Given the greater difficulty in maintaining appropriate acid-base balance in older adults,[16] balanced solutions such as plasmalyte or lactated Ringer's, rather than normal saline, should be used when able to avoid contribution to or development of hyperchloremic metabolic acidosis and further renal dysfunction.[46] The emergency physician should use cardiac POCUS or prior echocardiographic documentation to determine if right heart strain, diastolic dysfunction, or reduced ejection fraction necessitate a slower infusion to prevent exacerbating heart failure or precipitating pulmonary edema.

Patients with hemorrhagic shock should be transfused with whole blood (packed red blood cells, plasma, platelets) in 1:1:1 fashion,[47] preferably by activating a prearranged massive transfusion protocol, while working toward emergent, definitive hemorrhage control.[47–49] Crystalloid infusions should be strongly avoided, if possible, to prevent hemodilution and hypothermia, both of which worsen coagulopathy.[50] Reversing therapeutic anticoagulation using the appropriate reversal agents is necessary; in immediately life-threatening hemorrhage associated with anticoagulation, prothrombin complex concentrate should be given emergently.

Depending on the etiology, permissive hypotension should be allowed to avoid disrupting fragile clots only until definitive source control can be obtained. Data extrapolated from trauma research demonstrate benefits to targeting lower systolic (>70–80 mm Hg) and mean arterial pressures (>50 mm Hg) in cases of hemorrhagic shock,[51] and the Society for Vascular Surgery recommends targeting systolic pressures of 70 to 90 mm Hg in cases of ruptured abdominal aortic aneursym.[52] Although analyses using data from the National Trauma Data Bank National Sample Program indicate that presenting systolic blood pressures less than 110 mm Hg are associated with increased mortality rates in patients older than 60 years,[53] a later study did not find evidence of interaction between age and initial blood pressure on mortality.[54] Prompt, definitive hemostasis remains key to prevent prolonged hypoperfusion to organ systems and to improve outcomes regardless of age.

The appropriate hemoglobin transfusion goals in nonbleeding older patients is debated. The current recommendation remains to target a goal hemoglobin level greater than 7 g/dL based on critical care literature supporting this practice,[55,56] but it is worth noting that a more recent meta-analysis examining non–critically ill, mostly postsurgical patients older than 65 years found a mortality benefit with a more liberal transfusion strategy[57] and further investigation is needed.

Cardiogenic Shock

There are much higher incidences of primary cardiac illness, such as heart block or myocardial infarction (MI) in older adults. Roughly 6.5 million US adults have heart failure,[58] an increasing proportion of which have preserved ejection fraction.[59] When heart function is worsened or there is development of new heart failure secondary to an acute insult such as MI or PE, treatment of the underlying pathology with support of cardiac function is key and may require pharmacologic, electrical, or mechanical support. A cardiogenic component to shock can accompany other types of shock as well, as in stress cardiomyopathy.

Determining mixed shock states without ultrasound can be difficult. Mixed venous oxygen ($ScvO_2$) less than 70% from a superior vena cava central line or peripheral intravenous central catheter could be indicative of cardiogenic shock,[60] but may fail to detect the cardiac component in states of decreased oxygen requirement, such as neuromuscular blockade,[61] or high blood flow with decreased extraction, such as sepsis.[62] Likewise, it would be incorrect to assume cardiogenic shock in high-demand states such as after a seizure, in hypoxemic states such as acute respiratory distress syndrome (ARDS), or in the setting of severe anemia.[63]

Epinephrine at inotropic doses (0.01–0.05 μg/kg per hour) is generally recommended in the emergency department due to the easy titratability and vasoconstrictive effects of epinephrine, which can obviate the need for other vasopressors. Dobutamine and milrinone, while providing good inotropic effect, usually cause peripheral vasodilation that often requires the addition of norepinephrine. In the case of cardiogenic shock secondary to acute MI, norepinephrine is recommended over epinephrine due to higher incidence of refractory shock with epinephrine use.[64] Emergency physicians should be prepared for secondary arrhythmias arising from use of inotropic medications given their arrhythmogenicity[65] and the increased propensity of the older and critically ill populations to develop arrhythmias such as rapid atrial fibrillation or ventricular tachycardia.[12,66,67] In borderline hypotensive patients or those on vasopressors, the options to manage these rhythms are limited to relatively hemodynamically stable medications such as digoxin (for atrial fibrillation) or slow amiodarone bolus, or even electric cardioversion if hemodynamics are worsened.

Distributive Shock

In patients with distributive or septic shock, existing evidence supports the avoidance of overaggressive IV fluid resuscitation[68,69] and points to potential benefits with early administration of vasopressors.[70] Although the Surviving Sepsis Campaign guidelines make a general recommendation for a mean arterial pressure goal of 65 mm Hg or greater in septic shock,[71] the recent 65 Trial indicates that a lower goal of 60 mm Hg may be a safe alternative in patients older than 65 years.[72]

Additional IV fluid administration after an initial bolus should ideally be given only if patients demonstrate fluid responsiveness by passive leg raise and ultrasound[41] or by pulse pressure variability.[73] Although the Surviving Sepsis Guidelines suggest following the lactate levels to determine additional need for crystalloid,[71] a large, multicenter, randomized controlled trial found that lactate was no better than capillary refill

to gauge resuscitation, and the cohort relying on lactate clearance demonstrated a trend toward worsened mortality.[34] Lactate-based fluid resuscitation often leads to excessive IV fluid administration, a practice increasingly linked to either no improvement[74] or harm.[75] Elevated lactate is associated with greater mortality, but because it rises with beta-adrenergic stimulation,[76] its failure to clear is an indicator of ongoing stress, often independent from volume resuscitation status.[77]

Current guidelines in septic shock call for early source control, appropriate antibiotics, and norepinephrine as the first-line vasopressor, vasopressin as a second-line agent, and stress dose steroids considered in cases of refractory shock.[71] Older age by itself is not a contraindication to surgical intervention; however, if the patient's comorbidities and acute illness make them a poor surgical candidate, a frank discussion with the patient and family should be had regarding alternative options such as potential interventional radiology involvement.

MANAGEMENT OF RESPIRATORY FAILURE IN THE OLDER ADULT

Standard management of respiratory failure should be pursued in older patients with escalation from supplemental oxygen to high-flow nasal cannula to noninvasive ventilation, and finally to invasive mechanical ventilation as appropriate, depending on the level of oxygenation and ventilatory support needed and the patient's advance

Table 2
Difficulties associated with intubation in the older patient

Physiology	Significance	Mitigation Strategy
Increased incidence of poor dentition, edentulousness[78]	Increased risk of dental injury/ aspiration Poor seal with bag-valve-mask	Consider leaving dentures in during bagging (with care to avoid aspiration and removal before laryngoscopy)
Decreased muscle mass[78]	Poor seal with bag-valve-mask	
Decreased hypoepiglottic ligament integrity[79]	Floppier epiglottis, more difficult to "lift" during DL	Consider using Miller blade for DL or hyperangulated blade with VL
Cervical spine arthritis and/or prior fusion[78]	Limited atlantooccipital joint extension for vocal cord visualization	Use VL or FB as primary method[78]
Decreased:[14] • Baseline oxygen tension • Chemoreceptor sensitivity • Functional reserve • Chest wall compliance	More effort to preoxygenate Faster desaturation when apneic	Use apneic oxygenation[80] • Stable saturations: maintain level of respiratory support (NIV, HFNC)[81] until RSI • Refractory hypoxia: escalate to NIV[a] for preoxygenation[81] until RSI or place SGD[82]
Higher Mallampati scores Decreased thyromental distance	Difficult vocal cord visualization	Have backup airway adjuncts (eg, bougie, VL) ready[78]

Abbreviations: DL, direct laryngoscopy; FB, fiberoptic bronchoscopy; HFNC, high-flow nasal cannula; NIV, noninvasive ventilation; RSI, rapid sequence induction; SGD, supraglottic device; VL, video laryngoscopy.

[a] If not contraindicated.

directives. Should intubation be necessary, the emergency physician should be aware of inherent difficulties and have a plan for their management (**Table 2**).

Rapid sequence induction (RSI) is generally safe in older patients[83,84] as long as hemodynamics are stabilized before induction. Etomidate, a commonly used medication touted for its hemodynamically stable profile, can still cause or exacerbate hypotension in under-resuscitated patients,[85] and using half the standard dose (0.15 mg/kg rather than 0.3 mg/kg) should be considered. A similar dose adjustment is recommended with propofol, which is known to have hypotensive and negative inotropic effects. Ketamine has been demonstrated to be as safe as or safer than etomidate in critically ill patients requiring intubation,[86,87] owing to its positive effects on blood pressure via sympathomimetic effect. This sympathetic activity also includes, however, secondary tachycardia, which can worsen arrhythmias or cause increased myocardial demand and potential ischemia in the elderly heart. It should be noted that in patients with refractory shock and catecholamine-depleted states, the administration of ketamine can lead to cardiovascular collapse.[88,89]

After intubation, ventilator settings should be adjusted to lower the fraction of inspired oxygen (Fio_2) to less than 60% as soon as possible to avoid oxygen toxicity. An initial positive end-expiratory pressure (PEEP) setting of 5 to 8 cmH_2O is reasonable, with a higher range (8–12 cmH2O, for example) for obese patients. Higher PEEP strategies targeting lower driving pressures are recommended as the starting point for patients with moderate to severe ARDS, but these recommendations are conditional on maintaining plateau pressures less than 30 cmH_2O.[90,91] In general, lung protective ventilation strategies per the ARDSNet trial are also recommended[92] although the more recent PReVENT trial supports the safety of intermediate tidal volumes in patients without ARDS,[93] which would be preferable to inducing heavy sedation for the sole purpose of ventilator synchrony.

ADVANCE DIRECTIVES AND GOALS OF CARE

Older patients may request limits on invasive life-prolonging treatments. In one study of octogenarians living independently, more than a quarter refused noninvasive positive pressure ventilation, nearly half declined invasive mechanical ventilation, and 63% declined renal replacement therapy after intubation.[94] Early identification of advance directives in the critically ill older patient is crucial for physicians to determine appropriate management strategies going forward.

If predefined advance directives do not exist, it is important to learn what level of personal function and capability would be in line with their priorities should they survive. Focusing on the patient's wishes unburdens family members and directs the conversation toward concrete goals rather than vague possibilities. An informed determination by the medical team as to whether reaching the desired goal is likely and whether it will involve immediate or future invasive interventions, possible ventilator dependence, or prolonged institutionalization can inform patient and family decision making. If the prognosis is not apparent, it remains imperative that the discussion is at least initiated to ensure that care going forward continues to center on the patient's ultimate happiness and personal goals of care.

When discussing treatment plans, it is important that they are not characterized as "doing everything" versus providing less care, but rather that the team's maximum effort will be made to achieve the patient's personal goals, whether the goal is to live as long as possible or to die with comfort prioritized. There should be no judgment of which goals of care are appropriate, but it is the physician's responsibility to communicate which goals are unattainable.

SUMMARY

Older patients make up an increasing portion of the population and have both a physiologic predisposition to illness and comorbidities that increase the odds of critical illness and death. The presentation of acute severe illness may be subtle and special attention must be paid to changes in mental status, the shock index, capillary refill time, and tachypnea to detect critical illness and intervene early. Resuscitation should be guided by frequent physical reassessment augmented by ultrasound and an understanding of aging physiology. Patients' advanced directives and personal goals of care should be sought early, with guidance offered to patients and their families regarding the risks and long-term effects of intensive care.

CLINICS CARE POINTS

- Advance directives and goals of care should be discussed early, basing the focus of care on the patient's wishes for themselves.
- The lack of fever, tachycardia, hypotension, or severe pain is unhelpful to rule out acute severe illness. Assessment of mental status, the shock index, and capillary refill time are better indicators of perfusion status and potential shock state.
- Management of the various shock states is *generally* the same; geriatric patients are at higher risk for pulmonary edema and arrhythmias in response to fluid resuscitation and intravenous catecholamines, and may require less aggressive options if they are too sick for otherwise-recommended surgical intervention.
- Aggressive fluid resuscitation for shock should be neither proscriptive nor solely based on lactate clearance. Use additional markers of perfusion and POCUS to determine need for additional IV fluids versus peripheral vasopressor or inotrope administration.
- Older patients have a decreased functional reserve and can rapidly decompensate to respiratory failure, with inherent roadblocks to successful intubation. Anticipation of these roadblocks with ready mitigation strategies is key.
- The standard medications for RSI are generally safe in older patients, but decreased dosing of sedative agents is recommended and patients should be hemodynamically stabilized as much as possible before RSI is initiated.

DISCLOSURE

The authors have nothing to disclose.

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