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Namita Jayaprakash
Henry Ford Health, njayapr1@hfhs.org

Pflaum-Carlson

Jayna Gardner-Gray

Gina Hurst

Victor Coba

See next page for additional authors

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Authors
Namita Jayaprakash, Pflaum-Carlson, Jayna Gardner-Gray, Gina Hurst, Victor Coba, Harish Kinni, and John Deledda

Critical Care Delivery Solutions in the Emergency Department: Evolving Models in Caring for ICU Boarders

Namita Jayaprakash, MB BcH BAO, MRCEM*; Pflaum-Carlson, MD; Jayna Gardner-Gray, MD; Gina Hurst, MD; Victor Coba, MD; Harish Kinni, MD; John Deledda, MD

*Corresponding Author. E-mail: njayapr1@hfhs.org, Twitter: @kerala1220.

The National Academy of Medicine has identified emergency department (ED) crowding as a health care delivery problem. Because the ED is a portal of entry to the hospital, 25% of all ED encounters are related to critical illness. Crowding at both an ED and hospital level can thus lead to boarding of a number of critically ill patients in the ED. EDs are required to not only deliver immediate resuscitative and stabilizing care to critically ill patients on presentation but also provide longitudinal care while boarding for the ICU. Crowding and boarding are multifactorial and complex issues, for which different models for delivery of critical care in the ED have been described. Herein, we provide a narrative review of different models of delivery of critical care reported in the literature and highlight aspects for consideration for successful local implementation. [Ann Emerg Med. 2020;■:1-8.]

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INTRODUCTION

Peter Safar, a founding father of critical care medicine (CCM) in the United States, described critical care as a continuum from the out-of-hospital setting to the ICU. The ED, as a portal for entry to the hospital, serves as an anchor within this continuum. The number of patients presenting to the ED in the United States continues to increase, with approximately 1.5 million of these visits resulting in admission to critical care units.[1,2] This magnitude of patient volume has overwhelmed the capacity of many EDs, leading to crowding and prolonged boarding of patients awaiting ICU admission. Crowding and related ICU boarding are associated with a longer duration of intubation, increased risk of mortality, and increased length of stay.[3-7] An ED length of stay of greater than 6 hours is estimated to be associated with a 10% increase in hospital mortality.[8] ED crowding is thus recognized by the National Academy of Medicine as a health care delivery problem.[9] This narrative review aims to provide a brief discussion regarding approaches to potential solutions for delivery of critical care for ICU boarders in the ED.

CROWDING AND BOARDING OF CRITICALLY ILL PATIENTS IN THE ED

Causes of crowding in EDs are complex and multifactorial, but often attributed to increasing presentation volumes as well as a lack of available ICU beds.[10-12] A primary determinant is ineffective throughput, reflective of a limited supply of beds, inadequate staffing for the available beds, or ineffective use of beds. Mullins et al reported that between 2002 to 2003 and 2008 to 2009, ICU admissions from EDs increased by 48.8%.[10] Between 2000 and 2010, the number of US hospitals with available CCM or ICU beds decreased by 17%, whereas the US population increased by 9.6%.[13] Wallace et al[14] reported that according to Centers for Medicare & Medicaid Services, growth in the number of ICU beds from 2000 to 2009 was primarily in regions with larger populations and fewer ICU beds per 100,000 capita, who tend to have higher ICU occupancy rates.

The design of an ED is classically focused on providing rapid triage, resuscitation, stabilization, and initiation of treatment before determination of a disposition. ICU boarders force a shift requiring the delivery of longitudinal critical care in the postresuscitation phases of critical illness while patients await admission.[15,16] This may include ongoing hemodynamic monitoring, initiation of prophylaxis medications, and titration of ventilation. Depending on the duration of boarding, follow-up interventions may be required, including initiation and reconciliation of outpatient medications and redosing of scheduled medications, including antibiotics. Simultaneously, the emergency physician is required to reevaluate these patients while task switching to evaluate

new arrivals (Figure). This contributes to cognitive burden and strain on emergency physicians.

POTENTIAL SOLUTIONS FOR DELIVERING CRITICAL CARE FOR ICU BOARDERS

The subspecialty of emergency medicine and CCM continues to expand. Initially, this comprised a group of emergency physicians interested in pursuing training in the field of CCM, despite a lack of formalized board-certification pathways. Today, in its current state, there are 288 diplomates certified in the subspecialty of critical care through American Board of Emergency Medicine–cosponsored certification pathways.[17] The effect is increased availability of physicians with an expertise in both the resuscitation of critically ill patients and delivery of longitudinal critical care.

The growth of the subspecialty provides an opportunity to consider focused and diverse solutions to the challenges posed by crowding and ICU boarding. Various models for delivery of critical care in the ED have been proposed and described in the literature. Largely, these can be organized into geography-themed and personnel-focused models.

The Table provides an overview of current models of delivery of critical care in the ED, highlights important considerations for implementation for each, and gives examples of institutions that have adopted each model.[18-21]

GEOGRAPHY-THEMED MODELS OF DELIVERY OF CRITICAL CARE

Expediting Admission to the ICU

An idealistic approach to crowding and prolonged ICU boarding would be to expedite the admission process such that ICU beds are ready and available for patients being admitted from the ED. Initiatives in the United Kingdom to admit patients to the hospital within 4 hours of ED presentation may have improved sepsis care, as observed in the Protocolised Management in Sepsis (PROMISE) and Australasian Resuscitation in Sepsis Evaluation (ARISE) trials.[22,23] Early ICU admission not only improves the processes of care but also contributes to diminishing mortality in high-risk patients.[8,24-26] Grieve et al,[25] using a person-centered instrumental variable approach, found that the benefits of ICU care may increase among patients at high levels of baseline physiologic severity across different age groups, especially among elderly patients. These types of results can be applied to lobby for enhanced resources to increase the number of available ICU beds.

The United States and the United Kingdom have established that early ICU admission not only improves the processes of care but also contributes to diminishing mortality in high-risk patients.[8,24-27] However, expediting admissions to the ICU is complex, resource intensive, and heavily dependent on capacity. With increasing ED crowding, this model would require either expansion of the number of ICU beds or an increase in the availability of existing ICU beds. To achieve this goal, health care systems often need to lean on increased financial, space, and personnel burdens to create more beds or focus on processes to reduce waste and enhance ICU throughput for existing beds. Thus, this is not a quick or easily adoptable solution to the increasing demands and strains of ED crowding and boarding. Furthermore, ICU capacity is beyond the control of ED leadership.

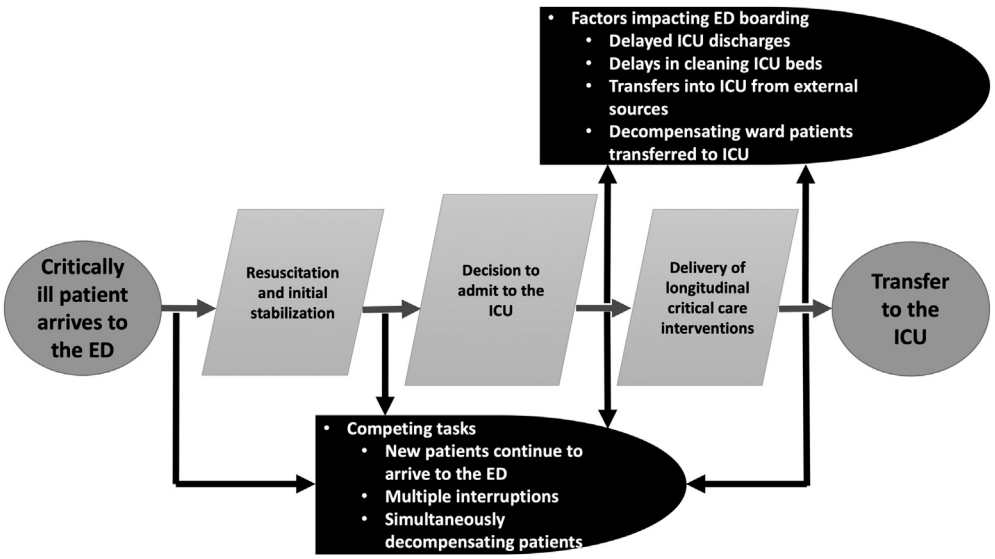

Figure. An overview of the process for the critically ill patient from ED arrival to ICU admission.

Table. An overview of models of delivery of critical care and considerations for implementation.

	Geography-Based Models			Personnel-Focused Models	
Model	**Expediting Admission to ICU**	**Hybrid ED-ICU**	**ED-ICU or RCU**	**ICU-Based Critical Care Consultation Model**	**ED-Based Critical Care Consultation Model**
Considerations for implementation	Space: ICU-based service Beds: limited by availability of ICU beds Throughput effect: process map of current and future state	Space: designated area within or adjacent to ED. Beds: reallocation of existing beds as hybrid ED-ICU beds or creation of newly assigned beds. Throughput impact: identification of ED throughput bottlenecks. Hybrid unit manages patients from triage, utility for problem of increased ED presentation volume.	Space: independent physical space adjacent to or within ED Beds: new beds with increased nurse-to-patient ratios Throughput effect: dependent on goal of unit (ie, increase transfers from outside hospitals, accommodate decompensating inpatients, admit directly from ED)	Space: no additional space required Beds: ICU clinicians go to patients, no additional beds Throughput effect: help take burden off inpatient ICU teams; improve delivery of longitudinal critical care needs; assume care of ICU boarder in the ED; enhance value-based care	Space: no additional space required Beds: clinicians based in ED go to ICU boarders, no additional beds Throughput effect: improve delivery of longitudinal critical care needs; burden off ED teams; act as bridge between ED and ICU; enhance value-based care
	Identify all stakeholders: level of hospital, department, revenue cycle, system leadership				
Resources	Extra ICU nurses or clinicians if ICU at capacity	Shared resources with ED for clinicians, nursing staff, respiratory therapist, unit clerks, other ancillary staff	Clinicians: physicians (emergency and CCM, emergency medicine with specific training in CCM), advanced practice clinicians, trainees (residents, fellows) Nursing: increased nurse-to-patient ratio Ancillary staff: designated respiratory therapists, clerks, ED technicians for unit	Clinicians: ICU physicians, advanced practice clinicians, critical care fellows	Clinicians: emergency and CCM physicians, ICU physicians based in the ED, emergency physicians with expertise in critical care (additional focused training, eg, FCCS course); advanced practice clinician; critical care fellows; residents
Examples of institutions that have used model	Ideal state most health care systems strive for is NHS, UK: person-centered instrumental variable approach	Henry Ford Hospital category 1 area of ED, Detroit, MI Stony Brook University Medical Center, Stony Brook, NY	University of Michigan EC3, Ann Arbor, MI University of Maryland Medical Center CCRU, Baltimore, MA University of Pennsylvania, Philadelphia, PA	Einstein/Montefiore Division of Critical Care Medicine "ICU without walls," Bronx, NY	Henry Ford Hospital early intervention team, Detroit, MI Stanford University School of Medicine, Palo Alto, CA

RCU, Resuscitation care unit; *FCCS*, fundamental critical care support; *EC3*, Emergency Critical Care Center; *CCRU*, Critical Care Resuscitation Unit; *NHS*, National Health Service.

The Hybrid Model

The hybrid model includes a focused high-acuity area within the traditional ED layout to provide timely aggressive care to patients presenting with critical illness.[18,21] This model is in some ways a precursor to the newer ED-ICU models. The hybrid model functions within the infrastructure of the ED and has the ability to more rapidly adapt to the needs of the ED during crowding. In this model, patients are triaged to the high-acuity area through traditional ED triage processes, which may include Emergency Severity Index levels of 1 or 2. However, the hybrid unit is also designed to meet the needs of the ICU boarder and deliver continued focused longitudinal critical care with flexibility.

After a cost analysis of the Early Goal-Directed Therapy in the Treatment of Severe Sepsis and Septic Shock study for severe sepsis and septic shock, which revealed a costs savings of $11.5 million per year and reduction in hospital days of 3,800 per year, Henry Ford Hospital upgraded an area of the ED to provide a dedicated space for monitoring and treating critically ill patients. The nursing and clinician ratios were also supported with a focus of delivering timely aggressive care in this new category 1 area.[19] The Henry Ford Hospital hybrid category 1 unit includes 2 resuscitation bays and 16 ICU-capable ED beds with the capacity to accept patients recognized early in the ED triage process as needing a high level of monitoring and focused critical care. The category 1 area is additionally designed to have the flexibility to serve some of the longitudinal care needs for ICU boarders. This hybrid area is staffed by a senior emergency attending physician, a senior emergency medicine or emergency medicine/internal medicine resident (postgraduate year 3 or above), and a junior resident (postgraduate year 2). In addition to physicians and nurses, there is a respiratory therapist and ED pharmacist who provide care for these high-acuity patients.

Stony Brook University Medical Center's Resuscitation and Acute Critical Care space is a 22-bed hybrid ED-ICU with an area that includes 2 resuscitation bays, 3 critical care rooms, and 16 beds. Acting as an extension of the ED, the space's high-acuity area is designed to accept patients who have met ED triage criteria but may require more intensive care or monitoring.[21]

ED-ICU Site-Based Model

The ED-ICU site, in contrast, is a separate space within the traditional ED layout or adjacent to it, functioning more as a typical ICU. It is staffed by a team of physicians and nurses specializing in CCM. In the United States, ED-ICUs or resuscitation care units can be found in centers such as University of Maryland Medical Center, Stonybrook University Medical Center, University of Michigan, and University of Pennsylvania.[21] ED-ICUs or resuscitation care units are designed to best serve local institutional needs. They can range from having an inpatient ICU status that allows facilitation of an increased number of out-of-hospital ICU transfers, functioning as an admitting service for ICU boarders, or being a unit consulting on and gradually assuming the critical care responsibilities for ICU boarders.[21] The ED-ICU space has the potential to benefit short-stay ICU admissions, which can be up to 38% of all critical care admissions.[28]

In France, Amiens University Medical Center created a 6-room ED-ICU unit within a 19-room ED. It operates continuously with a dedicated care team composed of emergency physicians, nurses, and nursing assistants. The creation of this unit allowed the introduction of protocols for suspected strokes within the window of eligibility for intravenous thrombolysis. Patients were either directly brought to the ED-ICU by paramedics or referred from ED triage by the triage nurse. After the implementation of the stroke protocol for the ED-ICU, the rate of thrombolysis in suspected strokes improved from 5.8% before the creation of the ED-ICU to 9.3% afterward (P=.02).[29]

The implementation of the Emergency Critical Care Center at the University of Michigan has been associated with a reduction in the risk-adjusted 30-day mortality among all ED patients, with a number needed to treat of 333 patient encounters.[30] An associated decrease in the risk-adjusted rate of ED to ICU admissions allowed use of the ICU beds for decompensating general floor or ward patients or transfers from outside institutions.[30,31] The risk-adjusted rate of ED to ICU admissions decreased from 3.2% in the pre–Emergency Critical Care Center cohort to 2.7% in the postcenter cohort (adjusted OR 0.80; 95% CI 0.76 to 0.83).[30] At the University of Maryland Medical Center, Scalea et al[32] reported a 64.5% increase in all critical care transfers, with a reduction in lost admissions, after the opening of the Critical Care Resuscitation Unit.

PERSONNEL-FOCUSED MODELS OF DELIVERY OF CRITICAL CARE

ICU-Based Critical Care Consultation Model

Many strategies have been tested for the provision of intensivist-directed care for critically ill patients boarding for the ICU.[18-20] In the ICU-based model, an inpatient critical care consultation team takes over the responsibility of care of a patient identified as critically ill, regardless of the location within the hospital. This includes ICU boarders in the ED. This model requires critical care

consultation teams to often provide remote care across multiple areas.[20] This model can alleviate the emergency physician's cognitive burden of providing longitudinal care to ICU boarders and improves the ability to deliver ICU level of care for the ICU boarder in the ED. It has drawbacks, with a lack of prompt availability of the consulting team, along with less oversight and coordinated care. Engoren[33] identified that a delay in intensivist evaluation after ICU admission was associated with a 1.6% increase in hospital mortality for each hour of delay. Thus, delays related to remote care may have the potential to contribute to adverse outcomes, although this has not been evaluated in a model in which ICU-based critical care consultation takes place in the ED.

ED-Based Critical Care Consultation Model

Alternatively, an ED-based model is one in which a dedicated team of physicians within the ED has site-defined responsibilities for the care of the critically ill patient or ICU boarder. Henry Ford Hospital in Detroit, MI, was an early adopter of the ED-based critical care consultation model. In the early 2000s, after the physical space of the ED was upgraded to accommodate the hybrid category 1 high-acuity area, a dedicated consultation team titled the early intervention team was able to assist in delivering focused critical care and optimize early interventions.[19] This adoption accommodated interventions such as early initiation of extracorporeal membrane oxygenation for patients in cardiac arrest.[34]

The original early intervention team physicians were primarily a mix of emergency physicians with specialized training in CCM or a focused interest in CCM, able to prioritize delivering focused early critical care and leave their colleagues to focus on departmental throughput. The growth of the subspecialty of emergency medicine and CCM has increased the number of board-certified emergency medicine and CCM specialists in the United States. Henry Ford Hospital has benefited from this growth because 7 board-certified emergency medicine and CCM specialists are part of the medical group, with anticipated growth in the near future. In light of increasing challenges of crowding and boarding of critically ill patients, despite availability of the category 1 hybrid unit, the availability of more emergency and CCM physicians allowed the modern early intervention team to form as a combination of ICU- and ED-based consultation models. It includes emergency and CCM physicians who can provide a critical care intensivist consultation service centered in the ED. The service is available Monday through Friday, 2 PM to 10 PM, focuses on the delivery of optimal critical care for patients who are boarding for the ICU, and includes optimizing longitudinal ICU care. This emerging model of using emergency medicine and CCM board-certified physicians who are able to base themselves in the ED and provide intensivist coverage can also be found at other centers such as Stanford University.[35]

One of the advantages of the ED-based critical care consultation model over the geography-themed ED-ICU model is related to capital savings in terms of the building or development of a physical space. This hybrid consultation model is of appeal to hospital settings that have restricted real estate expansion opportunities or limited flexibility related to finances. Furthermore, emergency and CCM physicians who work in both the ED and ICU settings strengthen relationships between the 2 departments and affirm the continuum of delivery of critical care that Peter Safar once described. They bring with them a familiarity with ED work flow and ED-based diagnostics, bedside camaraderie, and familiarity with ED-based coding and billing practices, which allows them to easily transition between settings. An ED-based consultation model reduces the burden of an inpatient consultation team to also cover the domain of the ED, potentially reducing the time to consultation.

The ED-based hybrid critical care consultation model, much like the geography-themed hybrid model, places the financial burden with the ED. The costs, however, of supporting the emergency and CCM physician team can be offset by the delivery of complex care in the ED through enhancement of critical care billing opportunities and increased relative value units. Further opportunity exists in adding value by ensuring timely recognition of sepsis, severe sepsis, and septic shock while enhancing 6-hour sepsis bundle compliance; optimizing ventilator adjustments with addition of needed prophylaxis; and decreasing the morbidity related to ICU boarders.

CONSIDERATIONS FOR IMPLEMENTATION OF MODELS OF DELIVERY OF CRITICAL CARE IN THE ED

Hospital and ED-Based Needs Assessment

A local needs assessment must guide selection of the optimal model of delivery of critical care in the ED. Primarily, this needs assessment should focus on some key elements:

a. Identifying stakeholders
   Regardless of the type of model of delivery of critical care, identifying the key departmental and hospital stakeholders is important for introduction,

maintenance, and evolution of the program or unit.

b. Evaluating ED throughput for the critically ill
When the most appropriate model is selected, it is important to understand where the holdup occurs for patients who are admitted to the ICU from the ED. Various local needs will influence the type of hybrid model or ED-ICU/resuscitation care unit that is the best fit. For example, a need for increased capacity lends itself more to a geography-themed model, whereas a need to provide early critical care expertise in the ED favors a consultation model. It is also important to consider and identify which types of patients will be admitted to the unit: ED admissions and inter- or intrahospital transfer patients needing ICU level of care. There may be opportunities to combine models as local needs evolve.

c. Determining bed capacity
Understanding current ICU bed use practices may help optimize the expedited admission to ICU model. However, in light of challenges of continued crowding, this may be temporary but potentially cost-effective. An ED-ICU or resuscitation care unit can function to expand the ICU capacity of the hospital. The impetus for the creation of the University of Maryland's Critical Care Resuscitation Unit in 2013 was to facilitate inter- and intrahospital transfers. Similarly, the University of Pennsylvania's Resuscitation and Critical Care Unit opened in 2017 to accommodate their local need.[21] A hybrid ED-ICU may better satisfy the holdups related to crowding and increased ED patient volumes.

d. Determining availability of resources
Aside from capital investment, additional physicians or advanced practice clinicians, nurses, and ancillary clinicians such as respiratory therapists and unit clerks are necessary resources for a successful ED-ICU or hybrid unit. Hybrid units have the advantage of sharing existing infrastructure and resources in terms of ancillary personnel such as respiratory therapists or unit clerks. Centers with postgraduate training programs and residency or fellowship curricula need to adapt to incorporate rotational experiences through the new ED-ICU or hybrid unit.
Variation exists among hospital systems regarding primary management of ICU boarders. ED clinicians who continue to primarily manage patients after ICU disposition may experience greater value in assistance from a consultation team for longitudinal cares.

INVESTMENT AND PLANNING

The up-front financial capital investment of a geography-themed model should be factored into planning and may be a rate-limiting step in many health care systems. The personnel-focused models overcome this investment by using existing infrastructure and focusing on allocation of clinician time in the planning and implementation phases. Costs can be limited to the full-time equivalent of the clinicians. Charge capture may range from evaluation and management charges related to ICU-based intensivist services to critical care billing. Revenue generation for an ED-based consultation service includes opportunities to enhance critical care billing in addition to the value of critical care expertise in delivering complex care in the ED. Ultimately, the incorporation of models of delivery of critical care in the ED may have its greatest influence in terms of relative value units.

The development of all the models requires investments of time and resources, along with the financial commitment. Training for nurses and clinicians and maintenance of certification programs are investments for their success. Familiarity with the process of development of protocols and guidelines for transitions of care outside the ICU is integral. These short-term investments are potentially offset by enhancement of value-based care.

WORKFORCE

As emergency medicine and CCM grows as a subspecialty, there will be an increasing number of board-certified specialists. However, with only 288 specialists at the writing of this article, the prospect for universal coverage across the United States with emergency and CCM physicians for these various models remains limited. Systems should consider processes for certification, credentialing, and maintenance of expertise. For example, the University of Michigan Emergency Critical Care Center requires that all non–emergency medicine and CCM board-certified specialists, including physician assistants, undertake a 2-day fundamental critical care support course every 2 years and participate in ongoing critical care continuing medical education lectures, chart reviews, and division meetings.[21]

LOOKING TOWARD THE FUTURE

The evolution of the models of delivery of critical care in the ED provides opportunities for emergency medicine and CCM board-certified specialists in terms of jobs,

leadership, and opportunities to enhance patient safety initiatives and patient-centered outcomes. The literature and evidence for each of these models are currently limited. As more centers incorporate focused critical care delivery models in their EDs, it is imperative to evaluate the effect these models have on value-based and patient-centered care. Some publications have begun to highlight the effect of some of these models on patient-centered outcomes.[8,25,30,36,37] Although in this review we discuss the existing geography-based and personnel-focused models that have been reported in the literature, we acknowledge a lack of data regarding the national scope and extent of use of various critical care delivery models across the United States. A better understanding is needed regarding the value and financial implications of shifting more consistent delivery of critical care to the ED. Currently, there is a paucity of available information about the financial models for delivery of critical care in the ED. This highlights a knowledge gap and opportunity for emergency medicine and CCM specialists to partner with health care systems to evaluate financial influences and the value added when various models of delivery of critical care are introduced in the ED. As the subspecialty of emergency medicine and CCM continues to expand, it is imperative for us to understand the existing use of delivery of critical care in the ED and gain an understanding of current practice patterns of emergency medicine and CCM specialists. The formation of emergency medicine and CCM task forces helps address these knowledge gaps and may help identify key aspects for developing common metrics, recognizing challenges, and planning.

CONCLUSIONS

Crowding and boarding of critically ill patients in the ED is not a novel issue but one that continues to affect work flow. Various models of delivery of critical care in the ED have been proposed and tested to address the challenges that come with evaluating and resuscitating new patients while providing longitudinal critical care to ICU boarders. As the workforce increases to include more emergency and CCM board-certified physicians, an opportunity exists to change the existing models of care.

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Author affiliations: From the Department of Emergency Medicine (Jayaprakash, Pflaum-Carlson, Gardner-Gray, Hurst, Coba, Kinni, Deledda), Division of Pulmonary and Critical Care Medicine (Jayaprakash, Pflaum-Carlson, Gardner-Gray, Hurst, Kinni), and Surgical Critical Care (Coba), Henry Ford Hospital, Detroit, MI.

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