ICU

MANAGEMENT & PRACTICE

INTENSIVE CARE - EMERGENCY MEDICINE - ANAESTHESIOLOGY

VOLUME 18 - ISSUE 1 - SPRING 2018

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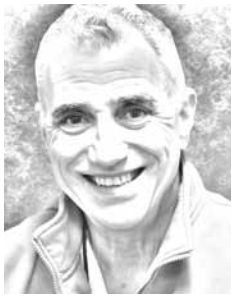
Lia I. Losonczy[1,2,3]



Thomas Scalea[1,4]

Jay Menaker[1,4]

Quincy Tran[1,2,4], James O'Connor[1,4], Brooke Andersen[4], Theresa DiNardo[5], Karen Doyle[4], Deborah Stein[1,4], Samuel Tisherman[1,4], Lewis Rubinson[1,4]

Affiliations:

1. University of Maryland School of Medicine, Baltimore, MD
2. Department of Emergency Medicine, R Adams Cowley Shock Trauma Center, University of Maryland Medical Center, Baltimore, MD
3. Division of Pulmonary and Critical Care Medicine, Department of Medicine, University of Maryland Medical Center, Baltimore, MD
4. Program in Trauma and Trauma Critical Care, R Adams Cowley Shock Trauma Center, University of Maryland Medical Center, Baltimore, MD
5. R Adams Cowley Shock Trauma Center, University of Maryland Medical Center, Baltimore, MD

The critical care resuscitation unit

A new paradigm for optimising inter-hospital transfer of patients with non-trauma time sensitive critical conditions

The number of clinical conditions which have improved outcomes associated with shorter time to specialised resuscitation and definitive intervention continues to increase. Many of these time-sensitive conditions have improved outcomes at high volume centres, but these centres are also challenged by limited intensive care unit (ICU) availability to reliably accept patients within optimal time windows. The University of Maryland Medical Centre/R Adams Cowley Shock Trauma Center (UMMC/STC) is a regional referral centre for complex critically ill and injured patients. To optimise care for non-trauma critically ill persons with time-sensitive high-risk conditions, we created an innovative unit, the Critical Care Resuscitation Unit (CCRU), that combines the pace and throughput of emergency departments with the depth and breadth of critical care intervention usually only available at specialty-specific academic intensive care units.

The CCRU provides resuscitative critical care that spans most adult specialties. The CCRU team prioritises patient referrals and provides medical direction for care during transport. It is optimised for immediate resuscitation upon arrival, and institutes prompt collaboration with subspecialty services for rapid intervention when warranted. The CCRU staff also work hand in hand with the staff in downstream definitive treatment locations for the patient (e.g. specialised intensive care units and intermediate care units) to ensure bed availability for the next patient. Previously we have reported that this 6-bed unit, which represents 3.8% of adult critical care beds at UMMC/STC was associated with a 64.5% increase in total critical care transfers, with a 93.6% increase in critically ill surgical patients in its first year of operation. Given this paradigm changing way of how most adult non-trauma critical care transfers come to UMMC, we sought to summarise the CCRU care model and processes to inform other referral centres seeking to improve their capacity and capability to care for critically ill time-sensitive transfers.

In the United States, patients with time-sensitive critical illnesses typically access care at their local hospital's emergency department (ED). Most hospitals are community based, and only a fraction of patients initially present to a tertiary care hospital (American Hospital Association 2017). Patients with critical conditions exceeding the resources of a community hospital require transfer to a higher level of care (Iwashyna et. al 2009; 2012). In addition to the requisite expertise, the accepting facility must have an available bed.

In the U.S., academic medical centres fulfil the role of referral hospital for most communities. These tertiary or quaternary centres generally have a higher proportion of critical care beds, but frequently do not have one immediately available, since they typically have higher occupancy rates (Wunsch et al. 2013). Hence, numerous critically ill patients

experience delays to specialised care for time-sensitive conditions (Cardoso et al. 2011).

Similar to other regions, the Delaware, Maryland, District of Columbia (D.C.) and Northern Virginia (DELMARVA) community hospitals have significant challenges when transferring patients. To ensure patients receive timely consultation, quality inter-hospital transfer care, immediate resuscitation and intervention on arrival, the University of Maryland Medical Center/R Adams Cowley Shock Trauma Center (UMMC/STC), created the Critical Care Resuscitation Unit (CCRU). We previously published our initial experience demonstrating decreased time to specialised care and an increase in transfer volume (Scalea et al. 2016). This paper describes the concepts, implementation and operation of the CCRU.

Before the CCRU

In the past decade, UMMC/STC experienced significant expansion of several specialty services, all of which have a component of emergency care: acute care emergency surgery, cardiac surgery with a burgeoning extra-corporeal membrane oxygenation (ECMO) programme, stroke service, neurosurgery and vascular surgery. Despite this growth, patients with time-sensitive emergencies frequently could not be transferred due to the lack of an immediately available intensive care unit (ICU) bed. Prior to opening the CCRU, 25% of critically ill patients referred to UMMC/STC could not be transferred. For those who were transferred, the median time from consultation to arrival was almost 4 hours (Scalea et al. 2016). The UMMC campus, which includes UMMC and the R Adams Cowley Shock Trauma Center (STC), has 148 adult ICU beds distributed across seven units and nearly 750 adult licensed beds. While this ratio exceeds the national average of ICU to total hospital beds (19.7% vs 12.4% (Wallace et al. 2015)), it was inadequate to accommodate many critically ill patient transfers.

ICU bed availability was not the only challenge. Coordination of care among subspecialty services and various ICUs was problematic. Also, workflow in a traditional ICU, which focuses on longitudinal care, is not ideally suited to manage multiple transfers of critically ill patients.

Lessons from the Maryland Trauma System: conceptual framework for design and implementation of the CCRU

Trauma care requires a comprehensive system, including pre-hospital providers, rapid transport and tiered levels of trauma hospitals, with distinct expertise and resources. For nearly five decades, Maryland made the vision of Dr. R Adams Cowley a reality by incorporating these essential components into a fully integrated, statewide trauma system.

The point of entry to the STC for injured patients, both from the field and transfers from other facilities, is the Trauma Resuscitation Unit (TRU), staffed 24/7 by a comprehensive trauma team led by an attending trauma surgeon. On arrival, the trauma team is already assembled allowing immediate assessment and interventions. The mature UMMC/STC trauma system, which cares for nearly 8,000 patients per year, has succeeded in part because critically injured patients are managed by immediately available, specialty-trained physicians, nurses and allied health professionals. It seemed reasonable to extrapolate this model of care delivery for non-traumatic, critically ill patients with time-sensitive conditions (Kahn et al. 2008).

CCRU model: multi-specialty resuscitation unit

More than one quarter of patients admitted to UMMC/STC are transferred from DELMARVA hospitals. Early in the conceptual phase focused on improving the transfer process, the question of who required urgent or emergent transfer was considered. Numerous studies have demonstrated that high-volume centres have improved outcomes for a wide range of surgical diseases, including complex gastrointestinal surgery (Gordon et al. 1999; 1995), craniotomies (Long et al. 2011) and cardiothoracic procedures (Finks et al. 2011; Cheung et al. 2009). An increasing amount of data demonstrates this effect is not exclusive to surgery (**Table 1**).

Patients cared for at centres specialising in acute stroke, acute coronary syndrome and cardiac arrest have shown improved outcomes (Campbell et al. 2015; Edwards and Carr 2010; Elmer et al. 2016; Spaite et al. 2014). This holds true for other serious conditions: subarachnoid haemorrhage (Berman et al. 2003), profound respiratory failure requiring mechanical ventilation (Lin et al. 2008; Peek et al. 2009), and severe sepsis (Peelen et al. 2007; Ofoma et al. 2017). A recent

Table 1. Volume-sensitive diseases and effects on outcomes

Patient population	Volume	Outcome
Mechanically ventilated patients	>400 per year	25.5% in-hospital mortality (Kahn et al. 2006)
	<150 per year	34.2 in-hospital mortality
ICU pneumonia	37-117 cases treated	14.3% mortality (Lin et al. 2008)
	118-314 cases treated	11.4% mortality
	>315 cases treated	8.1% mortality
Craniotomy	> 50 per year	2.5% in-hospital mortality (Long et al. 2003)
	< 50 per year	4.9% in-hospital mortality
Oesophagectomy	Very high volume	8.4% mortality (Birkmeyer et al. 2002)
	Very low volume	20.3% mortality
Pancreatectomy	Very high volume	3.8% mortality (Birkmeyer et al. 2002)
	Very low volume	16.3% mortality

Table 2. Time-sensitive diseases and effects of interventions

Type of disease	Outcome	Intervention
Aortic dissection, type A	Mortality 1% per hour	Not undergoing surgical intervention (Hagan et al. 2006)
Ruptured abdominal aortic aneurysm	Overall mortality rate 81% (Reimerink et al. 2013)	
	Mortality 40%	Intervention was delayed more than 45 minutes (Zdanowski et al. 2002)
Spontaneous intracerebral haemorrhage for patients with GCS > 8	12-month GOS > 3 = 33%	Operative treatment within 6-8 hours (Pantazis et al. 2006)
	12-month GOS > 3 = 9%	Medical management
Ischaemic stroke patients receiving tPA	72-hour neurologic improvement = 80% of patients	Endovascular therapy at less than 210 minutes from symptom Onset (Campbell et al. 2015)
	90-day modified Rankin Scale 0-2: 71%	
	72-hour neurologic improvement = 37%	Medical treatment
	90-day modified Rankin Scale 0-2: 40%	
Massive pulmonary embolism	Mortality 3.6%	Surgical embolectomy (Aymard et al. 2013)
	Mortality 13.5%	Thrombolysis

systematic review examining a wide range of critical illnesses reported that critically ill patients uniformly had improved outcomes at a high-volume, regionalised centre (Nguyen et al. 2015). In addition to volume-dependent disease outcomes, there are time-sensitive conditions for which the appropriate therapy is only available at select hospitals (e.g. type A aortic dissection, acute stroke amenable to clot retrieval (**Table 2**)).

For some emergency conditions (e.g. massive pulmonary embolism, severe pancreatitis, sepsis), the majority of patients arrive via inter-hospital transfers. Our analysis suggested a broad range of critically ill patients across numerous specialties would benefit from expeditious transfer to our facility. Since the impediment to transfer was frequently the lack of an available specialty ICU bed, we considered increasing bed capacity in some or all of the ICUs. We recognised that transfer requests are not uniformly distributed across time and would require maintaining an available ICU bed in each specialty unit. This was neither economically nor logistically feasible. Another option we considered was increasing ICU bed capacity only in select units. While this would increase transfer volume, the result would be patients boarding in a different subspecialty ICU. This may be detrimental, as several studies suggest that outcomes are worse when care is delivered in another specialty ICU (Mirski et al. 2001; Pascual et al. 2014). These challenges were the impetus to develop the CCRU: a multidisciplinary ICU that manages the spectrum of adults transferred with time-sensitive, critical illness. The CCRU was conceived as a "short-stay" unit, with the goal length of stay 6 to 12 hours. It would admit, resuscitate and stabilise patients, who eventually would be transferred to the operating room or appropriate specialty ICU, once a bed became available. Opened in July 2013, the CCRU is a 6-bed unit with 24-hour intensivist coverage.

> "designed to provide comprehensive critical care, not simply a landing zone for patients awaiting a destination ICU"

One of the lessons learned from the trauma model was the importance of immediate expert intervention as soon as the patient arrives. Therefore the CCRU was designed to provide comprehensive critical care, not simply a landing zone for patients awaiting a destination ICU. This necessitated an extremely broad scope of practice. In order to provide regional access for critically ill patient transfers, we needed the unit to have the personnel, equipment and systems to manage a spectrum of adult, non-traumatic critical illness.

A single unified ICU providing comprehensive critical care must be staffed with providers capable of working across the breadth of specialties. Prior to opening the CCRU we identified a cadre of ICU nurses with extensive and diverse critical care experience. Physician leadership and nurse educators implemented a rigorous and compressive training programme enabling the staff to be trained in all aspects of critical care. Unlike most critical care nurses with a depth of expertise within a focused specialty, the CCRU staff needed expertise across many specialties without compromising the knowledge inherent with subspecialisation.

The CCRU intensivist must also have expertise in rapid evaluation and resuscitation for all forms of critical diseases and be able to closely collaborate with various subspecialists. We determined that emergency medicine physicians with critical care fellowship training were ideally suited; they comprise the vast majority of the attending staff. The remainder are fellowship-trained medical and surgical intensivists with significant experience in both medical and surgical ICUs.

The intensivists work closely with the CCRU advanced practice providers (APPs), who are carefully selected based on extensive experience in an array of critical care settings

or formal fellowship training. They complete a three- to six-month orientation, including procedural simulation and skills labs. The APP works in tandem with the intensivist to manage resuscitations and coordinated care, allowing the physician to manage institutional and unit flow.

CCRU process overview: coordination and communication from the time of consult to definitive care

Pre-arrival coordination

A formalised transfer system is essential to coordinate referrals and prioritise transfers by illness severity and time sensitivity. Additionally, it must provide medical direction during transport. When a hospital requests a transfer to UMMC/STC, they contact the central transfer centre, Maryland Express Care (MEC), which coordinates approximately 11,000 transfers annually. MEC facilitates consultation between outside providers, CCRU and accepting services at UMMC/STC, provides ground transportation and coordinates aeromedical transport.

Prior to the CCRU, communication regarding transfer of critically ill patients between the accepting subspecialty and critical care services was informal and frequently limited. To improve this process, phone requests to MEC for transfer now include the referring physician, CCRU intensivist and the appropriate UMMC specialty attending. The CCRU intensivist prioritises transfers, determines the appropriate mode of transportation and provides medical oversight during transport.

MEC arranges the transport team, including at least one critical care nurse and one technologist with emergency medical team (EMT)-paramedic certification. For patients transferred for refractory respiratory failure and possible ECMO, a respiratory therapist is added to the team. When the team arrives at the referring hospital they contact the CCRU attending, provide updated information and receive medical direction when warranted.

Anticipatory posture

In order to reduce time to intervention once the patient arrives, the CCRU engages in "anticipatory posture", a concept used in military and political theory, which constitutes setting up for active engagement and pre-empting what is required to best address the situation before it presents itself (Larsen 2013). In this context, the CCRU team uses data from the initial consult, a standardised nurse report form (provided from referring nurse to CCRU nursing staff), the transport team's update, and the statewide health information exchange (Chesapeake Regional Information System 2017) to prepare infusions, pre-position equipment and anticipate likely procedural interventions. These include bedside decompressive laparotomy, ECMO cannulation, resuscitative endovascular balloon occlusion of the aorta (REBOA) insertion, oesophageal-gastric balloon device placement, endobronchial interventions, renal replacement therapy and apheresis as indicated. This process limits delays to critical interventions and reduces the organisational chaos associated with attempting to rapidly gather staff and equipment from multiple locations.

Attention to flow

By design, ICU workflows are structured to deliver longitudinal care rather than optimising care for the next admission. An unstable patient or several simultaneous admissions often disrupts this workflow. Conversely, the CCRU workflow focuses primarily on patient admission, resuscitation, stabilisation and disposition. The CCRU is a mixed model unit, incorporating the benefits of an ED as an access point centred on triage and flow, while concurrently delivering comprehensive multi-specialty critical care. Unlike many EDs, the providers can focus on the critically ill and are not distracted by myriad non-acute patients. Additionally, since specialists are involved in the initial consultation and decision to transfer the patient, there is no delay in specialty-driven care that occasionally occurs in the ED.

The CCRU is designed as a short-stay unit. Patients rarely require extended ICU care. However, if they do there are daily rounds as in any ICU, but rounds occur between new admissions. This workflow allows the CCRU team to maintain an anticipatory posture for the next critically ill patient transfer. This requires the CCRU attending and charge nurse to be in frequent communication with UMMC ICUs, procedural suites, operating rooms and the patient placement centre to facilitate disposition of CCRU patients.

Towards a culture of safely saying yes

We incorporated checks and balances to achieve defined goals in a safe, effective manner that consistently yields improved outcomes. Several key components are described below.

Requirement-based unit

Rather than fitting care into existing hospital systems, we created new systems based on the specific requirements of rapid diagnosis and emergent resuscitation. Unit design, processes and staffing models were developed to meet these requirements.

Optimising time to interventions

We developed guidelines which foster rapid treatment and mitigate existing barriers to care delivery. Examples include implementing a system providing emergency medications and infusions available prior to the patient's arrival or registration within the hospital's electronic medical record, as well as maintaining uncross-matched blood in the CCRU.

All cases are discussed directly with fellows or attending physicians. This allows junior trainees to be active learners without introducing treatment delays intrinsic to the traditional medical hierarchy. Additionally, the CCRU APPs provide continuity in this high-volume, high-acuity unit that may be challenging to accomplish in an academic model with rotating residents.

Quality assurance

To deliver care which is equivalent to that provided in UMMC specialty ICUs, the CCRU maintains a robust, non-punitive quality assurance system. We foster a culture among providers and staff to strive for constant improvement. Adverse events and opportunities for process improvement are documented daily by the charge nurse. When an area for improvement is identified, a system-level change is implemented and tracked to ensure the desired result is obtained.

Standardised, streamlined communication

Since medical errors are associated with transitions of care (Horwitz et al. 2008), handoffs

inherent in this model require a deliberate and standardised communication process. Detailed clinical information, including imaging, is obtained from the referring hospital; transport oversight and anticipatory posture are standard practice. At change of shift there is a face-to-face, detailed handoff between physicians, advanced practice providers and nurses.

Protocols and checklists

We created protocols, guidelines and checklists for high-risk procedures performed in the CCRU. Infrequently, a high-consequence emergency procedure (e.g. Minnesota tube, transvenous pacemaker, surgical airway, ECMO cannulation) is indicated and must be promptly and competently performed. Having immediately available guidelines and checklists minimises errors that may occur with these procedures.

Emergency inpatient rescue

With an almost omnipresent open bed, the CCRU is able to admit and stabilise decompensating UMMC/STC inpatients when no ICU bed is available (Jones et al. 2016). Rapid response personnel can quickly transport decompensating patients to the CCRU rather than continue resuscitation in a suboptimal, resource-limited environment. The CCRU can also decompress UMMC ED by admitting and managing critically ill patients awaiting an ICU bed, which has been shown to decrease mortality (Chaflin et al. 2007).

Limitations of model and areas for growth

While referrals to high-volume centres have been shown to be effective for many conditions, regionalisation has yet to demonstrate improved outcomes for all critical diseases. Studies have questioned transferring septic patients in rural settings (Mohr et al. 2016), and data are mixed on patients with ruptured abdominal aortic aneurysms (Mell et al. 2014). However, this may reflect delays in timely transfer and other logistical impediments. It is possible that an integrated, coordinated transfer system could mitigate these limitations, leading to improved outcomes. Clearly, further system development and evaluation are required.

Although some data demonstrate adverse outcomes for patients boarding in different subspecialty ICUs, it remains to be determined whether the CCRU model avoids this problem. That is another area that warrants future study.

To ensure an ICU bed is available, downstream flow must be a priority. Increasing overall admissions requires the receiving hospital must optimise patient throughput, including timely discharges.

Future directions and next steps

Currently, admissions to each subspecialty ICU are determined by the individual responsible for unit triage. We envision improved access and flow by having a single intensivist, with broad critical care experience, direct the ICU admission of all critically ill patients. Ideally, they would direct traffic across all ICUs within a regionalised system.

Although the CCRU has increased access to specialty care and transfers of critically ill patients, as well as decreased transport times (Scalea et al. 2016), prospective data collection is essential to fully understand the impact on patient outcomes. Additionally, the CCRU was created to address the needs specific at UMMC/STC and may be applicable to other institutions, but that remains to be determined. The CCRU is a template for delivering care to critically ill patients requiring transfer to a tertiary or quaternary centre. Others may adopt or modify the CCRU model to suit their particular institutional needs.

Conclusion

The CCRU has increased transfer volume and decreased time to definitive, specialty care for critically ill patients with time-sensitive conditions. This innovative unit ensures rapid access, medical control during transport, close coordination with specialty services and enhanced throughput. With a highly trained, dedicated staff focused on critically ill transfers, expeditious evaluation, appropriate interventions and close coordination with specialty services, the CCRU is a paradigm shift in care delivery. ■

Conflicts of interest and sources of funding

The authors have none to report.

Abbreviations

APP advanced practice providers
CCRU Critical Care Resuscitation Unit
DELMARVA Delaware, Maryland, District of Columbia (D.C.) and Northern Virginia
ECMO extracorporeal membrane oxygenation
ED emergency department
EMT emergency medical team
ICU intensive care unit
MEC Maryland Express Care
UMMC/STC University of Maryland Medical Center/ R Adams Cowley Shock Trauma Center
STC R Adams Cowley Shock Trauma Center
TRU Trauma Resuscitation Unit

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