



Published in final edited form as:

Emerg Med J. 2019 June ; 36(6): 364–368. doi:10.1136/emmermed-2019-208455.

Anatomy of resuscitative care unit: expanding the borders of traditional intensive care units

Evan Leibner^{1,2,3}, Rory Spiegel^{4,5}, Cindy H Hsu^{6,7}, Brian Wright^{8,9}, Benjamin S Bassin⁶, Kyle Gunnerson^{6,10,11}, James O'Connor², Deborah Stein², Scott Weingart⁹, John C Greenwood^{12,13}, Lewis Rubinson², Jay Menaker², and Thomas M Scalea²

¹Institute of Critical Care Medicine, Mount Sinai Hospital, New York, New York, USA

²Department of Surgery, Program in Trauma, R Adams Cowley Shock Trauma Center, University of Maryland School of Medicine, Baltimore, Maryland, USA

³Department of Emergency Medicine, Mount Sinai Hospital, New York, New York

⁴Department of Emergency Medicine, The University of Maryland Medical Center, Baltimore, New York, USA

⁵Department of Pulmonary Critical Care, The University of Maryland Medical Center, Baltimore, New York, USA

⁶Department of Emergency Medicine, Division of Emergency Critical Care, University of Michigan, Ann Arbor, Michigan, USA

⁷Department of Surgery, Division of Acute Care Surgery, University of Michigan, Ann Arbor, Michigan, USA

⁸Departments of Neurosurgery, Stony Brook University School of Medicine, New York, USA

⁹Department of Emergency Medicine, Stony Brook University School of Medicine, New York, USA

¹⁰Department of Internal Medicine, University of Michigan, Ann Arbor, Michigan, USA

¹¹Department of Anesthesiology/Critical Care, University of Michigan, Ann Arbor, Michigan, USA

¹²Department of Emergency Medicine, Perelman School of Medicine, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania, USA

¹³Department of Anesthesiology & Critical Care, Perelman School of Medicine, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania, USA

Abstract

Correspondence to: Dr Evan Leibner, Institute of Critical Care Medicine and Dept of Emergency Medicine, Mount Sinai Hospital, New York, NY 10029, USA; leibnere@gmail.com.

Contributors Manuscript was conceived edited by all authors. Writing was mainly done by ESL, RS, CH, JG, and BW.

Correction notice Since this journal was first published online, the author Cindy Hsu's name has been updated.

Provenance and peer review Not commissioned; externally peer reviewed.

Competing interests None declared.

Resuscitation lacks a place in the hospital to call its own. Specialised intensive care units, though excellent at providing longitudinal critical care, often lack the flexibility to adapt to fluctuating critical care needs. We offer the resuscitative care unit as a potential solution to ensure that patients receive appropriate care during the most critical hours of their illnesses. These units offer an infrastructure for resuscitation and can meet the changing needs of their institutions.

INTRODUCTION

Peter Safar, a pioneer of modern critical care and the second president of the American Society of Critical Care Medicine, defined critical care medicine as the combination of resuscitation, emergency care for life-threatening conditions and intensive care.¹ In his 1974 presidential address, Safar asserted that critical care is not defined by geographic location, but rather a set of principles designed to deliver appropriate and timely care to patients.² In the ensuing four decades, intensive care units (ICUs) have expanded to >3100 hospitals in the USA.³⁻⁸

Unfortunately, Safar's doctrine has since translated into specialty specific, geographically defined units rather than a location independent concept. Modern ICUs frequently focus on cohorts of patients with specific disease states,⁹ ignoring the fact that resuscitative efforts are often required outside the clinical jurisdiction of the ICU.

Critically ill patients in the emergency departments (EDs) also have time-sensitive critical care needs. Due to the severe shortage of ICU beds, these patients can remain in EDs for extended periods of time.¹⁰⁻¹³ Such delays often occur during the initial period of critical illness, when rapid and aggressive resuscitative efforts are required to ensure optimal outcomes.¹⁴ Treatment delays due to the lack of immediately available ICU beds are associated with worse outcomes.^{12,15-17} Simply expanding ICU bed quantity is not a sustainable solution as it is difficult to align dynamic clinical changes with appropriate bed availability.¹⁸ Furthermore, while many specialised ICUs provide excellent longitudinal critical care, they may be less equipped for initial resuscitation and stabilisation. Typical ICU workflow focuses on daily rounds to formulate and execute treatment plans. Newly admitted ICU patients often require full attention from the providers for an extended time due to their severely compromised physiology and multi-system failure. This can hamper the care delivered to the other ICU patients.^{16,17} In addition, community ICUs frequently do not have 24-hour intensivist coverage and may not be equipped to care for highly complex, critically ill patients during all hours of the day and night (10-12).

To address these unmet acute critical care needs, several institutions in the USA revisited Safar's critical care as a concept rather than location and have established resuscitative care units (RCUs). The University of Maryland Medical Center, University of Michigan, University of Pennsylvania and Stony Brook University Medical Center built RCUs to provide time-sensitive critical care. While each unit has been designed to meet its specific institutional needs, all RCUs focus on providing timely and specialised care to critically ill patients with diverse conditions and pathophysiology.^{19,20} This review describes and contrasts the mission, staffing, patient selection, and services provided by these RCUs.

University of Maryland School of Medicine Medical Center – Critical Care Resuscitation Unit

The impetus for Critical Care Resuscitation Unit (CCRU) was to provide an immediately available ICU bed for interhospital transfers of both medical and surgical patients who require an acute surgical intervention or have a time-sensitive critical illness that may benefit from a higher level of care. This six-bed unit (figures 1A and 2A) opened in July 2013 and is located in the R Adams Cowley Shock Trauma Center in Baltimore, Maryland. During its first year of operation, 1471 patients were admitted to the CCRU, resulting in a twofold increase in adult ICU transfers to the University of Maryland School of Medicine Medical Center (UMMC). The CCRU resulted in a 93.6% increase in critically ill surgical patients transferred to the UMMC while decreasing both transfer time and time to operating room.¹⁹

The CCRU is primarily staffed by emergency physicians with critical care fellowship training. They provide guidance to the referring physicians and are responsible for medical direction during transport. All CCRU nurses are required to have a minimum of 3 years of critical care experience and undergo comprehensive CCRU in-service training. Patients transferred to the CCRU are generally accepted prior to transfer by another service that has agreed to continue their management following their initial care in the CCRU. The CCRU provides rapid evaluation and resuscitation with immediate subspecialty consultations for a wide spectrum of time-sensitive critical illnesses (table 1). It is a versatile environment that can function as an ICU as well as an operating room.

Although its primary mission is to facilitate the rapid transfer of a critically ill patient to the UMMC, the CCRU also plays a key role in resuscitating decompensated ward and post-operative patients when ICU beds are not readily available. During its first year of operation, the CCRU cared for 194 of such decompensated patients.¹⁹ In addition to transfers from outside facilities and upgrades from the wards, the CCRU also accepts critically ill patients awaiting ICU beds from the UMMC ED.

Stony Brook University Medical Center – Resuscitation and Acute Critical Care Unit

Stony Brook's Resuscitation and Acute Critical Care (RACC) (figures 1C and 2C) is a 22-bed hybrid RCU. The goal of the RACC is to provide timely aggressive care to critically ill patients admitted through the ED when their care would be otherwise delayed because of the unavailability of ICU beds. The unit consists of two distinct care areas. The ACC area comprises three resuscitation bays and three critical care rooms. The remaining 16 beds form a high-acuity area. The latter takes patients who may have met triage criteria for the ED, but require additional nursing or clinical care, such as a haemodynamically stable patient who requires frequent neurological evaluations or a patient following naloxone administration requiring close monitoring of respiratory status. Having these two units under the care of one team allows full utilisation of nursing and provider resources when the critical care area is not being used at maximum capacity. The RACC is considered an extension of the ED, and patients are not considered admitted until they are accepted by an inpatient team.

The RACC is staffed 24 hours a day by emergency physicians with critical care training or with clinical interests in resuscitation and critical care. Two to three emergency medicine (EM) residents (junior doctors) are present for 19 hours daily with coverage dropping to a single resident for the remaining 5 hours. The unit is additionally staffed by two resuscitation fellows who are emergency physicians completing an additional year of training in resuscitation. The nurse to patient ratio when the unit is at maximum capacity is 1:2 for the critical care area and 1:4 in the high acuity area.

University of Michigan Emergency Critical Care Center

The University of Michigan is a tertiary academic medical centre with over 75 000 annual adult ED visits and unmet critical care demand. To decrease short-stay ICU admissions and improve inpatient critical care capacity, the Department of Emergency Medicine opened the Joyce and Don Massey Family Foundation Emergency Critical Care Center (EC3) (figures 1B and 2B) in February 2015.²¹ EC3 is a nine-bed ICU with five resuscitation bays that has since cared for approximately 2500 patients annually since its opening. Although providing ICU level care, EC3 is considered part of the ED and patients are not considered to be admitted to the hospital until they are formally admitted to an inpatient service. Patients are first evaluated and resuscitated by the ED team, with support from the EC3 team if necessary. If continued critical care and intensive monitoring is required after the initial period, then the care of these patients are transferred to the EC3 (table 1).²²

EC3 physician coverage is provided by EM faculty with or without formal critical care board certification, critical care fellows, physician assistants, EM residents and off-service residents (table 1). Those without formal fellowship training are required to attend a 2-day Fundamental Critical Care Support (FCCS) course every 2 years and participate in monthly critical care continuing medical education lectures, critical care division meetings and monthly chart reviews. Physician assistants are also required to obtain FCCS certification. There is always one attending (senior doctor [attending/consultant level]) and two providers from 11 am to 5 am, and one attending and one provider from 5 am to 11 am. EC3 nurses are required to undergo 2 months of intensive orientation in inpatient ICUs (one surgical and one medical unit). There is 2:1 patient to nurse ratio with an additional team lead nurse that may provide 1:1 assignment. In addition, the EC3 also share a dedicated respiratory physiotherapist and pharmacist with the ED at all time. The EC3 multidisciplinary team and patient care protocols ensure a seamless transition from the ED to the inpatient ICU and floor teams.

University of Pennsylvania Resuscitation and Critical Care Unit

The Resuscitation and Critical Care Unit (ResCCU) at the Hospital of the University of Pennsylvania (HUP) (figures 1D and 2D) is a five-bed RCU located within the Department of Emergency Medicine. The unit was designed to provide critical care services to both the HUP ED and time-sensitive critical care transfers from outside EDs (table 1). The ResCCU opened in February 2017, and during the initial pilot period, managed approximately 1000 critically ill patients who initially presented to the ED. Each patient is initially seen and managed by a primary ED team, with care rapidly transitioned to the ResCCU team if the patient requires prolonged critical care. Patients median length of stay in the ResCCU is 12

hours, with the goal of all patients being transitioned to an inpatient bed within 24 hours of arrival.

The Critical Care Division of the HUP Department of Emergency Medicine currently includes board-certified intensivists, along with emergency physicians with advanced resuscitation training (a 1-year resuscitation fellowship following residency training which focuses on the acute resuscitation of the critically ill). Emergency physicians without advanced training are expected to participate in weekly ED critical care case reviews to facilitate a standardised approach to ResCCU patient care. The ResCCU is staffed with a single attending and provider per shift. Providers include upper-level EM residents on a dedicated resuscitation rotation or a critical care advanced practice provider. ResCCU nurses include both CCRN and ED nurses who underwent an extensive orientation process over the course of 1–2 months. An initial orientation process included rotating through the HUP Heart and Vascular ICU, Neuro ICU and Surgical ICUs. ResCCU nurses are also included in the weekly critical care case review to ensure a high-level team approach toward complex patients.

DISCUSSION

The RCUs serve in different capacities to their institutions. Stony Brook's RACC is a hybrid unit rather than a stand-alone RCU. It accepts critically ill patients directly from prehospital providers, as transfers from outside EDs and from the main ED. In contrast, the EC3 and ResCCU function initially as consult services and assume ongoing critical care responsibilities after the initial evaluation and resuscitation by the primary ED team. This model enables continued training of the EM residents in the acute management of the critically ill patients and prevents over-triage.

The CCRU's primary function is to facilitate the rapid transfer of critically ill patients with time-sensitive diseases from community hospitals for definitive care. Unlike the other three RCUs, the CCRU is able to accept transfers from both outside EDs and ICUs due to its inpatient status. It has the additional capability of providing care for the decompensating ward patients when ICU beds are not readily available.

Challenges

Over-triage of non-critically ill patients is a common problem for RCUs, especially for the units housed within the Department of Emergency Medicine, as triage into the unit is quicker than disposition. Over-triage leads to non-critically ill patients occupying RCU beds and can hinder the ability of RCU to provide critical care during busy times.

Just as RCUs are vulnerable to over-triage, they can also face periods of under-utilisation. Identifying strategies for consistent room utilisation can be challenging for the RCUs. As the number of critically ill patients may wax and wane during different times and days of the week, the RCUs can use their resources for ED patients who require more intensive nursing care prior to their disposition. In addition, the RCU teams can also evaluate decompensating ward status patients boarding in the ED and assume their care if inpatient ICU beds are not immediately available.

The geographic location and appropriate size of RCUs should be carefully considered to meet their institutional needs. Under-appropriation or over-appropriation of space is problematic and cannot be easily remedied once a RCU has been built. Furthermore, as RCUs succeed in their mission, patients who are getting better may be downgraded from ICU-level patients to ward or stepdown status and can result in the boarding of these patients in the RCUs. The appropriate resource utilisation and allocation of non-ICU beds for RCU is a challenging topic that requires further research.

Finally, the maintenance of appropriate staffing and skill competency both in the RCUs and neighbouring units requires thoughtful consideration. The concern is RCUs potentially divert interesting and rewarding cases away from physicians and trainees not working in these units, diluting their experience and weakening their clinical skills. Constant communication with trainee leadership ensures that residents and fellows are being exposed to critically ill patients either during their time in the RCU or other hospital settings. In addition, education opportunities such as multidisciplinary seminars, critical care boot camp, simulation training and asynchronous learning can further enhance the clinical competency of providers staffing both the RCU and the ED. As described, RCUs have variable staffing models depending on their location and resources. Advanced practice providers can play an integral role in ensuring adequate staffing despite the at times inconsistent flow of fellows and junior doctors.

Future directions

While conceptually the RCUs offer several advantages, whether their existence benefits patients and provides logistical support to overburdened health systems remains under-explored. Scalea *et al* reported that with the opening of the CCRU in Maryland, critically ill surgical patient transfers almost doubled while their median arrival time decreased by half and median time to surgery by more than two-thirds.¹⁹ Bassin *et al* have observed similar success with the EC3 during its first 7 months of operation.²¹ Their preliminary data demonstrated a significant reduction in both ICU admissions per ED visit (2.5%–2.1%) and ICU admissions per hospital admission (7.2%–5.9%). This translates to four less ICU admissions per 1000 ED visits, potentially creating a surplus of 1186 ICU bed days during the study period. Extrapolated over a year, the EC3 may prevent 730 ICU admissions and eliminate 1897 ICU bed days.

Although RCUs may increase transfers and reduce ICU admission, more work is needed to fully understand their benefits. Do they effectively decompress the ED, allowing emergency physicians to focus their attention on the evaluation and management of their subsequent patients? Do RCUs provide distinct values compared with the addition of specialised ICU beds? Do the timely interventions provided by these units result in the improvement of patient-oriented outcomes? Finally, what financial implications do these units provide to prevent lost transfers, decreased patient length of stay and increased hospital throughput? Further research is necessary to examine the impact of RCU on patient outcome, resource utilisation and sustainability.

Each RCU should be designed to meet the unique resuscitation needs of the individual institution. For example, since the drafting of this manuscript, the University of Stanford

launched its Emergency Medicine Critical Care consult service.²³ The Emergency Critical Care Programme has no geographic location in the ED but rather evaluates critically ill patients boarding throughout the ED until they can be transferred to the appropriate ICU.

CONCLUSION

The concept of resuscitation did not begin with a specific place, but over the decades since Safar wrote his original paper, the ICU was created and this has led to artificial boundaries and differences in training. The ED, though excellent at the initial stabilisation of critically ill patients, is often overburdened and thus unable to appropriately care for them. Specialised ICUs, though excellent at providing longitudinal critical care, often lack the flexibility to adapt to fluctuating critical care needs. We offer the RCUs as a potential solution to ensure that patients receive appropriate care during the most critical hours of their illnesses. Not only can the RCUs offer an infrastructure for resuscitation, but they also enable adaptability to the changing needs of their institutions. As we continue to learn more about the acute phase of critical illnesses, additional RCU models may arise to meet other demands. We are excited to see what the future holds for RCUs and emergency critical care.

Funding

The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

REFERENCES

1. Safar P, Grenvik A. Critical care medicine. Organizing and staffing intensive care units. *Chest* 1971; 59:535–47. [PubMed: 4952918]
2. Safar P Critical care medicine---quo vadis? *Crit Care Med* 1974; 2:1–5. [PubMed: 4815738]
3. Groeger JS, Guntupalli KK, Strosberg M, et al. Descriptive analysis of critical care units in the United States: patient characteristics and intensive care unit utilization. *Crit Care Med* 1993; 21:279–91. [PubMed: 8428482]
4. Groeger JS, Strosberg MA, Halpern NA, et al. Descriptive analysis of critical care units in the United States. *Crit Care Med* 1992; 20:846–63. [PubMed: 1597041]
5. Halpern NA, Goldman DA, Tan KS, et al. Trends in critical care beds and use among population groups and medicare and medicaid beneficiaries in the United States: 2000–2010. *Crit Care Med* 2016; 44:1490–9. [PubMed: 27136721]
6. Halpern NA, Pastores SM. Critical care medicine beds, use, occupancy, and costs in the united states: a methodological review. *Crit Care Med* 2015; 43:2452–9. [PubMed: 26308432]
7. Halpern NA, Pastores SM, Greenstein RJ. Critical care medicine in the United States 1985–2000: an analysis of bed numbers, use, and costs. *Crit Care Med* 2004; 32:1254–9. [PubMed: 15187502]
8. Wallace DJ, Kahn JM. Florence Nightingale and the Conundrum of Counting ICU Beds. (1530–0293 (Electronic)).
9. Angus DC, Shorr AF, White A, et al. Critical care delivery in the United States: distribution of services and compliance with Leapfrog recommendations. *Crit Care Med* 2006; 34:1016–24. [PubMed: 16505703]
10. Derlet RW, Richards JR. Overcrowding in the nation's emergency departments: complex causes and disturbing effects. *Ann Emerg Med* 2000; 35:63–8. [PubMed: 10613941]
11. Trzeciak S, Rivers EP. Emergency department overcrowding in the United States: an emerging threat to patient safety and public health. *Emerg Med J* 2003; 20:402–5. [PubMed: 12954674]

12. Chalfin DB, Trzeciak S, Likourezos A, et al. Impact of delayed transfer of critically ill patients from the emergency department to the intensive care unit. *Crit Care Med* 2007; 35:1477–83. [PubMed: 17440421]
13. Singer AJ, Thode HC, Viccellio P, et al. The association between length of emergency department boarding and mortality. *Acad Emerg Med* 2011; 18:1324–9. [PubMed: 22168198]
14. Nguyen HB, Rivers EP, Havstad S, et al. Critical care in the emergency department: A physiologic assessment and outcome evaluation. *Acad Emerg Med* 2000; 7:1354–61. [PubMed: 11099425]
15. Cardoso LT, Grion CM, Matsuo T, et al. Impact of delayed admission to intensive care units on mortality of critically ill patients: a cohort study. *Crit Care* 2011; 15:R28. [PubMed: 21244671]
16. Cavallazzi R, Fau MP, Fau HA, et al. Association between time of admission to the ICU and mortality: a systematic review and metaanalysis. (1931–3543 (Electronic)).
17. Gabler NB, Fau WJ, Asch DA, et al. Mortality among patients admitted to strained intensive care units. (1535–4970 (Electronic)) doi: D - NLM: PMC3826272 EDAT-2013/09/03 06:00 MHDA-2013/12/16 06:00 CRDT- 2013/09/03 06:00 AID.
18. Gooch RA, Kahn JM. ICU bed supply, utilization, and health care spending: an example of demand elasticity. *JAMA* 2014; 311:567–8. [PubMed: 24408679]
19. Scalea TM, Rubinson L, Tran Q, et al. Critical Care Resuscitation Unit: An Innovative Solution to Expedite Transfer of Patients with Time-Sensitive Critical Illness. *J Am Coll Surg* 2016; 222:614–21. [PubMed: 26920992]
20. Weingart SD, Sherwin RL, Emlet LL, et al. ED intensivists and ED intensive care units. *Am J Emerg Med* 2013; 31:617–20. [PubMed: 23380127]
21. A Novel ED-based Critical Care Unit Reduces ICU Utilization. *Acad Emerg Med* 2016.
22. Haas NL, Gianchandani RY, Gunnerson KJ, et al. The Two-Bag Method for Treatment of Diabetic Ketoacidosis in Adults. *J Emerg Med* 2018; 54:593–9. [PubMed: 29628184]
23. Mitarai T Stanford Emergency Critical Care Program (ECCP): ACEP. 2018 <https://www.acep.org/how-we-serve/sections/critical-care-medicine/news/july-2018/stanford-emergency-critical-care-program-eccp/#sm.00001qg7cq8rwee5zqjjean47xflp2019>.

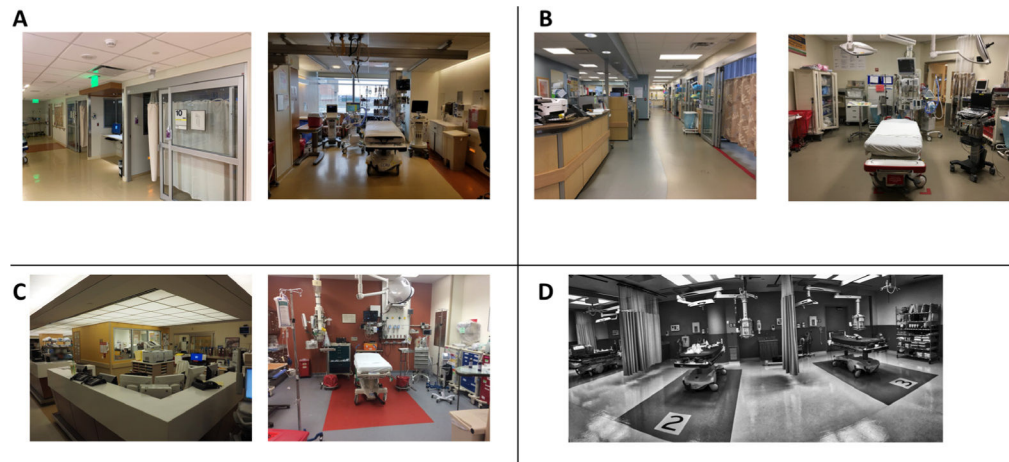


Figure 1.

Pictures of the resuscitation rooms and the RCU units. (A) University of Maryland CCRU, (B) University of Michigan EC3, (C) Stony Brook University RACC, (D) University of Pennsylvania ResCCU. CCRU, Critical Care Resuscitation Unit; EC3, Emergency Critical Care Center; RACC, Resuscitation and Acute Critical Care; ResCCU, Resuscitation and Critical Care Unit; RCU, resuscitative care unit.

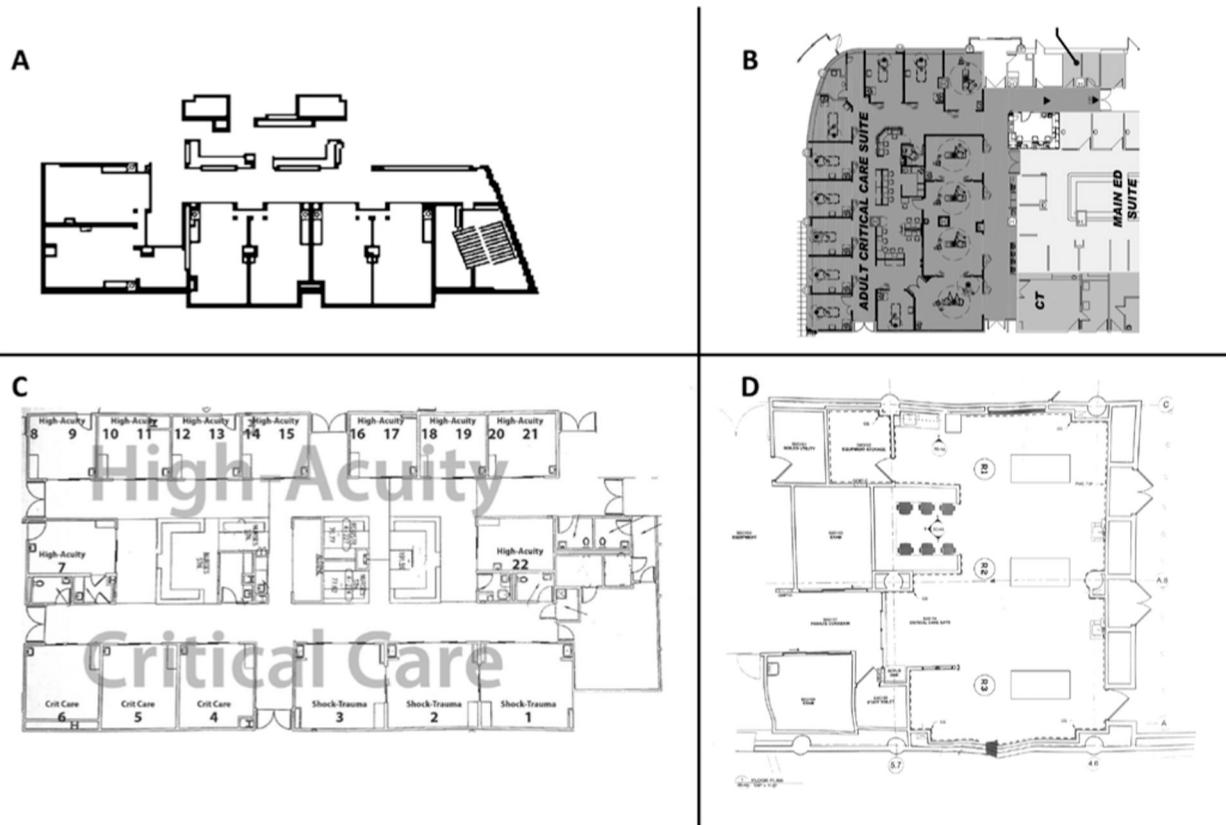


Figure 2.

Floor plans for the RCUs. (A) University of Maryland CCRU, (B) University of Michigan EC3, (C) Stony Brook University RACC, (D) University of Pennsylvania ResCCU. CCRU, Critical Care Resuscitation Unit; EC3, Emergency Critical Care Center; RACC, Resuscitation and Acute Critical Care; ResCCU, Resuscitation and Critical Care Unit; RCU, resuscitative care unit.

Comparisons of the different of the four RCUs: attending is equivalent to senior doctor: typically, >4 years postqualification equivalent to UK consultant level, resident equivalent to junior doctor typically between 1 and 4 years postqualification

Table 1

	University of Maryland School of Medicine/Medical Center - CCRU	Stony Brook University Medical Center - RACC	University of Pennsylvania – ResCCU	University of Michigan – EC3
Size	6 ICU rooms	3 Resuscitation bays 3 Critical care beds 16 High-acuity beds	3 Resuscitation bays 2–3 Stepdown rooms	9 ICU rooms 5 Resuscitation bays
Annual patient volume	~1500 Patients	~2500 Critically ill patients ~4000 High-acuity patients	~1000 Patients in first year	~2500 Patients
Department	R Adams Cowley Shock Trauma Center Department of Surgery	Department of Emergency Medicine	Department of Emergency Medicine	Department of Emergency Medicine
Staffing	1 Attending 1 Advanced practice provider 1 Charge nurse 4 Bedside nurses 1 Patient care technician 1 Respiratory therapist 1 Unit clerk	1 Attending 2–3 EM residents/APP 1 Scribe 1 Charge nurse 8 Bedside nurses 1 Unit clerk <u>Shared resources with ED</u>	1 Attending 1 PGY 2–4 EM resident or 1 Surgical critical care APP 2–3 Bedside nurses <u>Shared resources with ED</u> 1 Respiratory therapist 1 Clinical pharmacist	1 Attending 2 Providers (residents, fellows and physician assistants) 1 Charge nurse 4 Bedside nurses 1 Unit clerk <u>Shared resources with ED</u>
Patient access	Transfers from outside hospitals Floor upgrades ED admissions	1 Respiratory therapist 1 Clinical pharmacist ED admissions Transfers from outside EDs	ED admissions Transfers from outside EDs	1 Respiratory therapist 1 Clinical pharmacist ED admissions Transfers from outside EDs
Patient diagnoses	Acute neurological emergencies	ESI level 1, 2 and some 3 from triage	Acute liver failure	Acute neurological emergencies
	Acute respiratory distress syndrome Aortic emergencies Cardiogenic shock Haemorrhagic shock Intra-abdominal sepsis Septic shock Submassive/massive pulmonary embolism	Acute neurological emergencies Acute renal failure Acute respiratory distress syndrome Aortic emergencies Cardiogenic shock Haemorrhagic shock Septic shock	Acute neurological emergencies Acute respiratory distress syndrome Aortic emergencies Cardiogenic shock COPD exacerbation Diabetic ketoacidosis End of life care Haemorrhagic shock	Acute respiratory distress syndrome Aortic emergencies Cardiogenic shock COPD exacerbation Diabetic ketoacidosis End of life care Haemorrhagic shock

	University of Maryland School of Medicine/Medical Center - CCRU	Stony Brook University Medical Center - RACC	University of Pennsylvania – ResCCU	University of Michigan – EC3
	Renal failure Toxic overdoses		Submassive/massive pulmonary embolism Toxic overdoses	GI bleed and acute liver failure Postcardiac arrest care Renal failure Septic shock Submassive/massive pulmonary embolism Toxic overdoses
Special skills	VV ECMO VA ECMO IABP EVD REBOA CRRT MARS	VA ECMO VAD management EVD Leukapheresis/plasmapheresis Bronchoscopy Endoscopy SLED	VV ECMO VA ECMO EVD Lipophoresis Plasmaphoresis CRRT	VA ECMO VAD Intermittent haemodialysis Leukapheresis/plasmapheresis Bronchoscopy Endoscopy EVD

APP, advanced practice provider; CCRU, Critical Care Resuscitation Unit; COPD, chronic obstructive pulmonary disease; CRRT, continuous renal replacement therapy; EC3, Emergency Critical Care Centre; ED, emergency department; EM, emergency medicine; ESI, Emergency Severity Index; EVD, external ventricular drain; GI, gastrointestinal; IABP, intra-aortic balloon pump; ICU, intensive care unit; MARS, Molecular Adsorbents Recirculation System; PGY, post-graduate year; RACC, Resuscitation and Acute Critical Care; RCU, resuscitative care unit; REBOA, resuscitative endovascular balloon occlusion of the aorta; ResCCU, Resuscitation and Critical Care Unit; SLED, slow low-efficiency dialysis; VAD, ventricular-assisted devices; VA ECMO, veno-arterial extracorporeal membrane oxygenation; VV ECMO, venovenous extracorporeal membrane oxygenation.