Trends in Cardiac Critical Care
Reshaping the Cardiac Intensive Care Unit

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Coronary care units originated for the singular purpose of rapidly resuscitating patients from arrhythmic complications of acute myocardial infarction (MI) but have transformed into cardiac intensive care units (CICUs) that deliver comprehensive critical care for patients with cardiovascular diseases. Forged by a common clinical experience, recognition of this evolution by practitioners in the CICU preceded data that have quantified this transition. A series of single center and small multicenter studies, mostly in academic hospitals, have started to detail the progression of demographics, comorbid conditions, and procedures that characterize the contemporary CICU environment. Now, in this issue of *Circulation: Cardiovascular Quality and Outcomes*, Sinha et al extend this investigation to a national level. Their study contributes meaningfully to an expanding database that will facilitate evidence-based redesign of the structure, staffing, and organization of our CICUs.

Transformation of the CICU

At its core, this transformation of the CICU has been marked by a progressive decline in the need for critical care among patients with acute MI and expansion of other patient populations requiring cardiac critical care (Figure). Quinn et al first called attention to the diminishing role of the CICU in the care of ST-segment-elevation MI (STEMI) and quantified a shift in early resuscitation and reperfusion from the CICU to the Emergency Department in the United Kingdom. Katz et al then described associated changes in CICU practice with substantially more granularity in a retrospective examination of 29 275 patients admitted between 1989 and 2006 to the CICU at Duke University Medical Center. By the end of this period, although the median age remained 63 years, the demographics had swung toward greater representation of women (41%) and minorities (38%). Key findings were a decline in admissions for STEMI, from ≈40% of admissions in 1989 to ≈20% in 2006, and increases in admissions with sepsis (≈8% in 2006), acute kidney injury, liver failure, and other noncardiac conditions. The median Charlson Comorbidity Index increased from ≈1.7 to ≈2.2. Although coronary angiography and pulmonary artery catheterization (≈3% in 2006) decreased, mechanical ventilation and bronchoscopy increased. Notably, the unadjusted CICU mortality rate remained stable during this period (7.4% in 2004–2006). A subsequent multicenter study of all admissions in 2011 to multiple academic CICUs in New York reinforced the diminished contribution of STEMI. In a population with a median age of 67 years and 42% women, 26.3% of admissions were for STEMI. The CICU mortality rate across 6 hospitals was 5.6%, with a range from 2.2% to 9.2%. In a single center study of 1042 admissions in 2013 to 2014 to the CICU at University of Virginia, only 11% of admissions were for STEMI. In contrast, 50% of patients had presentations that included acute kidney injury, respiratory failure, or sepsis, each of which were independently associated with CICU mortality or length of stay. Of primary diagnoses, heart failure accounted for 15% and valvular heart disease 10%. Noncardiac primary diagnoses accounted for 14% of admissions, with sepsis as the fifth most common primary diagnosis at 5% and present in 16% of admissions.

Sinha and colleagues have now interrogated these trends at a national level in a retrospective study of 3.4 million acute care hospitalizations with CICU stays in the period from 2003 to 2013 using the Medicare Provider Analysis and Review files that capture all billable diagnoses and procedures, along with demographics and hospital outcomes for Medicare beneficiaries. CICU-specific revenue center codes within the claim records identified hospitalizations with a CICU stay. The principal finding of Sinha et al was a remarkable increase in the proportion of noncardiac primary diagnoses from 38.0% to 51.7% with a concurrent decline in primary diagnoses related to coronary artery disease from 32.3% to 19.0%. The increase in noncardiac primary diagnoses was explained primarily by infectious and respiratory diseases, with sepsis rising by 2013 to the second most common individual discharge diagnosis (9.2%) after acute MI (STEMI or non–ST-segment-elevation MI, 12.0%). The investigators also quantified medical comorbidity using the Elixhauser comorbidity system based on a set of 30 indicators, finding that the proportion with ≥3 indicators rose from 32.9% to 54.6%. Moreover, ≈50% of patients were women, and the fraction of the very elderly (≥85 years) rose to ≈25% in 2013. As in previous studies, renal failure was a dominant and growing noncardiac comorbid condition. Among cardiovascular conditions, heart failure, pulmonary vascular disease, and valvular heart disease increased in prevalence.
With these changes in the distribution of medical conditions in CICUs, the procedures implemented included greater use of positive pressure ventilation (≈15%) and renal replacement therapies (≈5%) while the use of pulmonary artery catheters declined to 1.1%, along with decreases in cardiac catheterization and coronary revascularization. By 2013, renal replacement therapy exceeded the use of pulmonary artery catheters and mechanical circulatory support combined. Patients with noncardiac primary diagnoses had more than double the rate of positive pressure ventilation and nearly double the rate of hemodialysis. Despite these shifts toward greater comorbidity, unadjusted mortality decreased from 9.3% to 8.9%.

**Current Landscape of Cardiac Critical Care**

Concurrent with these changes in demography, the organizational structure of CICUs also seems to be evolving. Two studies have surveyed the organization and staffing of CICUs in the United States. In 2012, a survey of 123 CICU directors (78% academic) reported that 68% had dedicated medical CICUs, 55% of which had intensive care unit–based attending staffing. Less than half of CICUs had routine involvement of a physician with intensivist skills, and only 4% were managed by a cardiac intensivist. In this issue of *Circulation: Cardiovascular Quality and Outcomes*, a larger survey, for which I was a coinvestigator, captured 612 centers from the American Heart Association Mission: Lifeline and American College of Cardiology ACTION Registry-Get-With-the Guidelines hospitals, including 62.4% community-based hospitals. In this contemporary survey, only 8.2% of centers had dedicated CICUs and 25.8% had unit-based staffing. However, >60% had routine involvement of an intensivist and 14.7% had dual-boarded cardiac intensivists practicing in the CICU. Although 52.7% of respondents indicated that their CICU would be classified as a level 1 CICU, only 10.8% of all CICUs met all aspects of the level 1 criteria, ranging from 26.1% of academic to 3.9% of community-based CICUs.

**Implications for the Road Ahead**

In aggregate, these observational studies have started to paint a more refined picture of the contemporary CICU and identify needs around which to focus care improvement. At least 6 key elements are revealed by these data. First, the CICU population in the United States is marked by a mounting proportion of the elderly and complexity of comorbid disease. Second, driven by major declines in case fatality and complications of acute MI, and improvements in the capabilities of intermediate care units, the original purpose of CICUs to anticipate life-threatening complications of acute MI has diminished in relevance. Third, heart failure, valvular disease, and, in some centers, pulmonary vascular disease have growing significance as cardiac primary diagnoses in the CICU. Fourth, at the same time, the proportion of patients with cardiovascular disease who present with other medical conditions or complications requiring critical care has also increased, leading to more noncardiac primary diagnoses in the CICU. Contrasting with the lower rate of noncardiac diagnoses (14%) in a single center study with physician review of each medical record, the proportion of noncardiac diagnoses (51.7%) in Sinha’s study is possibly overestimated by billing coding or reflects a higher proportion in community-based CICUs. However, the trend of a steady expansion of this population is compelling (Figure). Moreover, these conditions, particularly sepsis and acute kidney injury, are independently associated with mortality risk, alongside cardiac arrest and cardiogenic shock. Fifth, with these changes in the landscape of problems managed in the CICU, the make-up of diagnostic and therapeutic interventions is also changing. CICU patients are older, sicker, and are managed with more intensive care unit therapies, such as prolonged mechanical ventilation and renal replacement, that are associated with iatrogenic complications that contribute to intensive care unit cost, morbidity, and mortality. At the same time, care of less complicated patients is shifting progressively toward lower levels of in-hospital care. Sixth, partly in response to these transitions, the organization and implementation of cardiac critical care are manifesting an evolution of their own.

Although there are obvious limitations to comparing data from 2 different surveys of CICU structure and staffing, a qualitative assessment of temporal trends suggests a rise in the proportion of CICUs staffed by medical cardiac intensivists. However, the reports from O’Malley and van Diepen also reveal substantial heterogeneity in structure across CICUs. This variability makes sense and is not intrinsically adverse. In a simplistic view, communities do not need an extracorporeal life...
support center on every street corner. Studies of triage to CICUs for MI or heart failure care also reveal highly diverse practices across hospitals. This variability in the types of patients cared for across CICUs in the United States is reinforced by the striking range of CICU mortality rates. Nevertheless, for centers that house advanced (level 1) CICUs offering complex multidisciplinary care and medical technologies for problems, such as refractory shock and post-cardiac arrest syndrome, as well as for patients with cardiac disease who develop severe multiorgan system dysfunction, accumulating evidence supports the premise that approaches to care in the CICU also need to evolve to meet the changing needs of our patients.\(^1,2,10\)

Despite my assertion that one size will not fit all, the consistency of the observations from Sinha and colleagues across hospitals of widely varying size also has implications for healthcare leaders who are involved in clinical care redesign. The changes in the CICU population are not limited to large tertiary care centers but also are present in smaller community-based hospitals. Therefore, CICU and hospital leaders must examine their own population and patterns of care and tailor the organization of their CICU to the needs of their community and practice environment.

Studies, such as the one from Sinha et al, are imperative to crafting changes to continue improvement in CICU outcomes. They also forecast a mounting need for clinicians with specialized skills to function optimally in this environment. Since 2011, the cardiovascular training program at Brigham and Women’s Hospital has offered a pathway for our fellows wishing to train in Critical Care Cardiology. There are now a growing number of institutions with self-reported intent to offer specific pathways for Critical Care Cardiology training. Such efforts are likely to be necessary to meet the escalating interest in staffing with such trained providers.

**Summary**

It has been 5 years since an American Heart Association Scientific Statement Writing Group formulated a roadmap to meet the changing needs of critical care cardiology.\(^1\) In that period, there has been engagement of stakeholders in professional societies and cardiovascular training, as well as an emerging commitment to observational studies and clinical trials focused on elucidating and improving models of care in the CICU. Although evidence of progress is apparent, meaningful opportunities remain that challenge us to innovate in this changing environment of critical care cardiology. Sinha’s study reveals that the stakes are becoming progressively higher and we need to be prepared.

**Disclosures**

None.

**References**


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