Title

Presentation and Outcomes of Patients With Preoperative Critical Illness Undergoing Cardiac Surgery.

Journal
JACC: Advances, 2(2)

Authors
Metkus, Thomas
Alviar, Carlos
Baird-Zars, Vivian
et al.

Publication Date
2023-03-01

DOI
10.1016/j.jacadv.2023.100260

Peer reviewed

HHS Public Access
Author manuscript
JACC Adv. Author manuscript; available in PMC 2024 February 14.

Published in final edited form as:
JACC Adv. 2023 March ; 2(2): . doi:10.1016/j.jacadv.2023.100260.

Presentation and Outcomes of Patients With Preoperative Critical Illness Undergoing Cardiac Surgery

Thomas S. Metkus, MD, PhD[a], **Carlos L. Alviar, MD**[b], **Vivian M. Baird-Zars, MPH**[c], **Gregory W. Barsness, MD**[d], **David D. Berg, MD**[c], **Erin A. Bohula, MD, DPhil**[c], **James A. Burke, MD, PhD**[e], **Christopher B. Fordyce, MD, MHS, MSC**[f], **Jianping Guo, MAS**[c], **Jason N. Katz, MD, MHS**[g], **Ellen C. Keeley, MD, MS**[h], **Venu Menon, MD**[i], **P. Elliott Miller, MD, MHS**[j], **Connor G. O'Brien, MD**[k], **Shashank S. Sinha, MD, MSC**[l], **Derek So, MD, MSC**[m], **Bradley W. Ternus, MD**[n], **Sagar Vadhar, DO**[e], **Sean van Diepen, MD, MSC**[o], **David A. Morrow, MD, MPH**[c]

[a]Divisions of Cardiology and Cardiac Surgery, Departments of Medicine and Surgery, Johns Hopkins University School of Medicine, Baltimore, Maryland, USA;

[b]Leon H. Charney Division of Cardiology, NYU Langone Medical Center, New York City, New York, USA;

[c]Levine Cardiac Intensive Care Unit, TIMI Study Group, Cardiovascular Division, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, Massachusetts, USA;

[d]Department of Cardiovascular Medicine, Mayo Clinic, Rochester, Minnesota, USA;

[e]Lehigh Valley Heart and Vascular Institute, Allentown, Pennsylvania, USA;

[f]Division of Cardiology and Centre for Cardiovascular Innovation, University of British Columbia, Vancouver, British Columbia, Canada;

[g]Division of Cardiology, Duke University School of Medicine, Durham, North Carolina, USA;

[h]Division of Cardiovascular Medicine, University of Florida, Gainesville, Florida, USA;

[i]Cardiovascular Medicine, Cleveland Clinic Foundation, Cleveland, Ohio, USA;

[j]Department of Cardiovascular Medicine, Yale School of Medicine, New Haven, Connecticut, USA;

[k]Division of Cardiology, Department of Medicine, University of California-San Francisco School of Medicine, San Francisco, California, USA;

[l]Inova Heart and Vascular Institute, Inova Fairfax Medical Center, Falls Church, Virginia, USA;

[m]University of Ottawa Heart Institute, Ottawa, Ontario, Canada;

ADDRESS FOR CORRESPONDENCE: Dr Thomas S. Metkus, Division of Cardiology, Department of Medicine, Johns Hopkins Hospital, Blalock 524, D2, 600 N Wolfe Street, Baltimore, Maryland 21287, USA. tmetkus1@jhmi.edu.

The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

APPENDIX For supplemental tables, please see the online version of this paper.

[n]Division of Cardiology, Department of Internal Medicine, University of Wisconsin, Madison, Wisconsin, USA;

[o]Division of Cardiology, Department of Critical Care Medicine, Department of Medicine, University of Alberta, Edmonton, Alberta, Canada.

Abstract

BACKGROUND—Little is known about the prevalence and post-surgical outcomes associated with cardiac intensive care unit (CICU) therapeutics among CICU patients referred for cardiac surgery.

OBJECTIVES—The purpose of this study was to investigate the clinical characteristics and outcomes of CICU patients referred for cardiac surgery from the intensive care unit.

METHODS—We analyzed characteristics and outcomes of CICU admissions referred from the CICU for cardiac surgery during 2017 to 2020 across 29 centers. The primary outcome was in-hospital mortality.

RESULTS—Among 10,321 CICU admissions, 887 (8.6%) underwent cardiac surgery, including 406 (46%) coronary artery bypass graftings, 201 (23%) transplants or ventricular assist devices, 171 (19%) valve surgeries, and 109 (12%) other procedures. Common indications for CICU admission included shock (33.5%) and respiratory insufficiency (24.9%). Preoperative CICU therapies included vasoactive therapy in 52.2%, mechanical circulatory support in 35.9%, renal replacement in 8.2%, mechanical ventilation in 35.7%, and 17.5% with high-flow nasal cannula or noninvasive positive pressure ventilation. In-hospital mortality was 11.7% among all CICU admissions and 9.1% among patients treated with cardiac surgery. After multivariable adjustment, pre-op mechanical circulatory support and renal replacement therapy were associated with mortality, while respiratory support and vasoactive therapy were not.

CONCLUSIONS—Nearly 1 in 12 contemporary CICU patients receive cardiac surgery. Despite high preoperative disease severity, CICU admissions undergoing cardiac surgery had a comparable mortality rate to CICU patients overall; highlighting the ability of clinicians to select higher acuity patients with a reasonable perioperative risk.

Keywords

CABG; cardiac intensive care unit; cardiac surgery; ICU

The epidemiology of acute cardiovascular disease is changing, with increasing disease complexity and greater burden of non-cardiac comorbidities among critically ill cardiovascular patients.[1–3] Patients with cardiac critical illness may require surgical therapy with temporary or durable mechanical circulatory support,[4,5] coronary revascularization,[6] valve or aortic surgery,[7–9] and pulmonary embolectomy among others.[10,11] Patients in the cardiac intensive care unit (CICU) who require cardiac surgical therapy represent a complex, challenging, and potentially high-risk population. Multidisciplinary management teams incorporating cardiac surgery and cardiology have been advocated for common CICU diseases including complex patients with coronary disease,[12–18] endocarditis,[7,8] pulmonary embolism,[10,11] cardiogenic shock,[5,19] aortic dissection,[9] valve disease,[20] and ventricular tachycardia,[21] with the goal of optimizing patient selection and perioperative management through shared decision-making.

The outcomes of patients with cardiac critical illness requiring surgical consultation and surgical therapy merit clarification in the face of changing CICU epidemiology. An understanding of the presentation, comorbidities, and outcomes of different disease states treated with cardiac surgery in the contemporary CICU may help inform decision making by Heart Teams, provide baseline benchmarks to inform quality improvement efforts, and contribute to educational interventions in both cardiac surgery and cardiology programs. To address these knowledge gaps, we performed an observational study describing the scope of cardiac surgical practice in the contemporary CICU. We hypothesized that CICU patients would receive cardiac surgery for a diverse array of underlying conditions treated with critical care therapeutics prior to surgery and that surgical CICU patients would have high in-hospital mortality.

METHODS

STUDY POPULATION.

The Critical Care Cardiology Trials Network is a prospective research network of tertiary care CICUs across the United States and Canada.[1] The Executive and Steering Committees, data analytic center, and Coordinating Center are led by the Thrombolysis in Myocardial Infarction Study Group, Brigham and Women's Hospital (Boston, Massachusetts). Each institution captures clinical and outcomes data for all consecutive medical CICU admissions over a 2-month period each year. Centers may also choose to contribute data for additional consecutive admissions outside of the 2-month window. Data are abstracted directly from clinical charts by trained study staff at each site. Details of the study cohort, data abstracted, and the research protocol have been previously published.[22] The Institutional Review Board at the Coordinating Center as well as each participating site approved the Critical Care Cardiology Trials Network protocol and waiver of informed consent. The present study includes data from 2017 to 2020 from 29 centers.

DATA COLLECTION, EXPOSURES, AND OUTCOMES.

For all CICU admissions, centers collected demographics, admitting diagnosis, indications for intensive care unit (ICU) level of care, ICU therapies provided during the CICU stay, laboratory data, and Sequential Organ Failure Assessment score,[23] hemodynamic variables, length of stay, and in-hospital outcome, including death or discharge to home or skilled nursing facility. The exposure of cardiac surgical therapy was classified if the patient underwent any open-heart surgical procedure during or directly from their CICU stay, as reported on the case-report form from each center. Surgical procedures were not included for those patients who were stabilized and transferred out of the CICU prior to cardiac surgery. Percutaneous valve procedures were also excluded. The primary study outcome was in-hospital mortality. All data managers received standardized training with the electronic case report form, housed in the REDCap system.[24] Data are centrally reviewed and queried by the Coordinating Center to ensure consistency and internal validity.

STATISTICAL ANALYSIS.

Demographics, clinical characteristics, and outcomes are presented for all CICU patients undergoing cardiac surgery from the CICU and across the surgical subgroups of isolated coronary artery bypass grafting (CABG), valve repair or replacement (with or without CABG), left ventricular assist device (LVAD)/transplant, and other surgeries (pericardiectomy, aortic surgery, pulmonary thrombectomy, and others). The population of all other CICU patients who did not undergo cardiac surgery are also provided for comparison.

We performed logistic regression as a risk factor analysis to assess for an association of critical care therapies prior to cardiac surgery with mortality among cardiac surgical patients admitted to the CICU preoperatively. In separate models, we first adjusted for age, sex, and Sequential Organ Failure Assessment score and then for age, sex, race, creatinine, diabetes, presence of shock, and presence of acute myocardial infarction to assess for an association of mechanical ventilation, non-invasive ventilation or high flow nasal cannula, vasopressor/inotrope use, need for mechanical support, and renal replacement therapy with mortality among surgical patients. The Wilcoxon rank sum test was used to compare continuous variables and the Chi-square test for categorical variables. Results were considered statistically significant at a 2-sided P value <0.05. Analyses were performed using SAS System V9.4 (SAS Institute Inc).

RESULTS

PATTERN OF CARDIAC SURGICAL THERAPY IN THE CICU.

Among 10,321 CICU admissions, 887 (8.6%) underwent cardiac surgery, including isolated CABG in 406 (46%), transplant or ventricular assist device in 201 (23%), valve surgery (with or without CABG) in 171 (19%), and other procedures in 109 (12%), including aortic surgery, pulmonary embolectomy, pericardiectomy or pericardial window, intracardiac defect repair, cardiac mass removal, and myectomy. Among 3,504 CICU admissions with acute coronary syndromes, 352 (10.1%) underwent cardiac surgery, of which 319 (90.6%) were isolated CABG, 13 (3.7%) transplant or ventricular assist device, 12 (3.4%) valve surgery, and 8 (2.3%) other procedures. Of 3,241 CICU admissions with heart failure or cardiogenic shock, 322 (9.9%) received cardiac surgery, of which 72 (22.4%) were CABG, 58 (18.0%) valve surgery, 175 (54.3%) transplant or ventricular assist device, and 17 (5.3%) other procedures. “Other” operations include pulmonary endarterectomy, aortic surgery, and miscellaneous procedures such as atrial septal defect closure, pericardial stripping, or pseudoaneurysm repair.

PREOPERATIVE CLINICAL CHARACTERISTICS AND ICU MANAGEMENT.

Demographics and chronic comorbidities for CICU patients treated with cardiac surgery are shown in Table 1. CICU-cardiac surgery patients had a median age of 63 years (25th–75th percentiles: 52.0–71.0 years), 28.1% were female, 80.5% had LVEF ≤40%, 18.8% had history of atrial fibrillation, 20.9% chronic kidney disease, 18.9% were on dialysis, and 10.0% had significant pulmonary disease.

Indications for ICU admission for CICU patients treated with cardiac surgery are shown in Table 2; the most common indications for ICU care included shock in 33.5%, respiratory insufficiency in 24.9%, and need for vasoactive therapy without shock in 15.3%. Of CICU cardiac surgical patients, 10.4% had unstable arrhythmia and 5.0% had cardiac arrest as indications for initial triage to the CICU. The proportion of CICU cardiac surgical patients managed with advanced ICU therapies preoperatively are shown in Table 3 and included 52.2% receiving vasoactive therapy, 35.9% with mechanical circulatory support, 35.7% managed with mechanical ventilation, and 17.5% with high flow nasal cannula or noninvasive positive pressure ventilation. For CICU patients undergoing isolated CABG, 148 (36.5%) were treated with preoperative mechanical circulatory support. For those undergoing transplantation or ventricular assist device, 131 (65.2%) were treated with preoperative mechanical circulatory support. The most common indication in the overall surgical population for mechanical circulatory support was shock, while in the isolated CABG group, the most common indication was for critical left main or severe coronary disease (Supplemental Table 1).

POSTOPERATIVE IN-HOSPITAL MORTALITY.

Median CICU length of stay prior to cardiac surgery was 3.9 days (25th–75th percentiles: 1.7–11.0 days). For those undergoing isolated CABG, CICU length of stay preoperatively was 2.8 days (25th–75th percentiles: 1.3–5.7 days) while for those undergoing transplantation or LVAD, CICU length of stay preoperatively was 12.3 days (25th–75th percentiles: 4.9–22.0 days).

In-hospital mortality for CICU patients undergoing cardiac surgery was 9.1%, including 6.4% for those undergoing isolated CABG, 12.3% for valve surgery, 11.0% for those treated with transplant or LVAD, and 11.0% for those undergoing other cardiac surgical procedures (Central Illustration). The most common cause of death in cardiac surgical patients was heart failure/cardiogenic shock (Supplemental Table 2). Deaths occurred at a median of 4.8 days after leaving the CICU (median 4.8 days, IQR: 25.8 days). For CICU admissions during the study period not treated with cardiac surgery, the hospital mortality rate was 1,121 (11.9%) patients out of 9,434 admissions.

The association of pre-operative CICU therapeutics with in-hospital mortality is shown in Table 4. After adjusting for demographics and illness severity, only mechanical circulatory support, and renal replacement therapy were associated with postoperative mortality. Preoperative use of mechanical ventilation or non-invasive respiratory support and vasopressor use were not associated with postoperative mortality.

DISCUSSION

CICU patient complexity is increasing, and multidisciplinary team-based management of complex patients is recommended in many contemporary CICU conditions.[5,19,25] In this prospective cohort study of CICU patients treated with cardiac surgery, we report several novel findings. First, approximately 1 in 12 contemporary CICU admissions are treated with cardiac surgery. Second, CICU-cardiac surgical patients have a high prevalence of chronic comorbidities and complex preoperative acute critical illness. This impactful proportion of complex patients highlights a need for focused attention to multidisciplinary Heart Team care as a routine part of CICU practice. Third, despite high preoperative disease severity, CICU admissions taken to cardiac surgery had a comparable mortality rate to CICU patients overall; pointing to the ability of clinicians to select CICU patients at reasonable perioperative risk.

Our finding that nearly 9% of patients admitted to contemporary tertiary care CICU's receive cardiac surgical therapy has several implications. First, clinicians staffing CICU's require an understanding of management of the preoperative cardiac surgical best clinical practices. An additional implication of the high prevalence of cardiac surgical therapy in the CICU is that collaborative teamwork and decision-making between surgical teams and CICU teams serve to improve patient selection, decision making, and outcomes. This collaboration has been codified in multiple ways such as Heart Teams[14] and Shock Teams.[19,26] Irrespective of the framework for collaboration, the principles of collegial teamwork and bidirectional availability are foundational.

We describe the case mix and acute and chronic comorbidities of cardiac surgical patients who receive intervention from the CICU–46% of cases were isolated CABG while 23% of surgeries were for cardiac support with transplantation or LVAD. Transplantation and LVAD cases are over-represented in the CICU compared to general surgical practice, because of the CICU shock and heart failure populations.[1,4] These surgeries are multidisciplinary and highly regulated with multiple quality stakeholders.[27] Therefore, it is important that CICU leadership participate in quality efforts related to surgical care, including avoiding preventable harm.[28] Optimizing the medical status of chronic comorbidities described here, including diabetes, pulmonary disease, and chronic kidney disease, is likely key to realizing good surgical outcomes. We also identify that the proportion of women in the surgical groups is low. This finding is largely consistent with other cohort studies of surgical revascularization which demonstrate a higher proportion of men.[29,30] Other authors have postulated mechanisms for this disparity including older age at coronary artery disease presentation in women compared to men, and as yet unknown factors.[30,31] Addressing volume status[32] is also important, given our finding that over 80% of CICU patients treated with surgery had reduced EF.

In-hospital mortality rates after isolated CABG, valve surgery and cardiac support surgery are high in our study and while comparable to overall ICU mortality rates, are higher than the overall CABG population which is under 2%.[33] This information can be used for clinician prognostication, and for team-based decision making. That provision of mechanical support and renal replacement is associated with mortality is intuitive since higher-risk patients are more likely to receive these therapies.

STUDY LIMITATIONS.

Limitations of our study include its observational design, descriptive nature, and that causality of association cannot be determined. Moreover, it is likely that the specific preoperative therapies and the specific survival interventions are themselves associated with each other which limits our ability to determine truly independent associations between exposure and outcome. Rather, these data serve to define the scope of cardiac surgical therapy in the specialized setting of the CICU and serve as an impetus to future investigation and quality improvement. Our study includes tertiary care largely academic centers and therefore results are most generalizable to these types of CICU's. Finally, our database does not include standard cardiac surgical risk scores such as Society of Thoracic Surgeons Risk Score or intraoperative variables or postoperative complications known to be associated with mortality. The degree to which ICU therapeutics explains residual risk from the Society of Thoracic Surgeons model should be explored in future studies. Similarly, our database focuses on medical CICU care and so facets of postoperative care are not available.

CONCLUSIONS

Nearly 1 in 12 of contemporary CICU patients receive cardiac surgery. Despite high preoperative disease severity, CICU admissions taken to cardiac surgery had a comparable mortality rate to CICU patients overall; pointing to the ability of clinicians to select CICU patients at reasonable perioperative risk. These data should motivate institutions to empower Heart Teams and multidisciplinary care efforts and quality improvement efforts to improve outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

FUNDING SUPPORT AND AUTHOR DISCLOSURES

Dr Metkus has a relationship with TelaDoc-BestDoctors, Oakstone-EBIX, and McGraw-Hill. Dr Alviar is on the Speakers Bureau of Zoll Inc; and received research grant from Baxter medical. Dr Guo is a member of the TIMI Study Group which has received institutional research grant support through Brigham and Women's Hospital from Abbott, Amgen, Anthos Therapeutics, AstraZeneca, Daiichi-Sankyo, Eisai, Intarcia, MedImmune, Merck, Novartis, Pfizer, Regeneron Pharmaceuticals, Inc, Roche, The Medicines Company, and Zora Biosciences. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

ABBREVIATIONS AND ACRONYMS

CABG	coronary artery bypass grafting
CICU	cardiac intensive care unit
ICU	intensive care unit
LVAD	left ventricular assist device

REFERENCES

1. Bohula EA, Katz JN, van Diepen S, et al. Demographics, care patterns, and outcomes of patients admitted to cardiac intensive care units: the Critical Care Cardiology Trials Network prospective North American Multicenter Registry of Cardiac Critical Illness. JAMA Cardiol. 2019;4(9): 928–935. [PubMed: 31339509]
2. Jentzer JC, van Diepen S, Barsness GW, et al. Changes in comorbidities, diagnoses, therapies and outcomes in a contemporary cardiac intensive care unit population. Am Heart J. 2019;215:12–19. [PubMed: 31260901]

3. Sinha SS, Sjoding MW, Sukul D, et al. Changes in primary noncardiac diagnoses over time among elderly cardiac intensive care unit patients in the United States. Circ Cardiovasc Qual Outcomes. 2017;10:e003616. [PubMed: 28794121]
4. Berg DD, Barnett CF, Kenigsberg BB, et al. Clinical practice patterns in temporary mechanical circulatory support for shock in the Critical Care Cardiology Trials Network (CCCTN) Registry. Circ Heart Fail. 2019;12:e006635. [PubMed: 31707801]
5. Tehrani BN, Truesdell AG, Sherwood MW, et al. Standardized team-based care for cardiogenic shock. J Am Coll Cardiol. 2019;73:1659–1669. [PubMed: 30947919]
6. Bangalore S, Guo Y, Xu J, et al. Rates of invasive management of cardiogenic shock in New York before and after exclusion from public reporting. JAMA Cardiol. 2016;1:640–647. [PubMed: 27463590]
7. Kaura A, Byrne J, Fife A, et al. Inception of the ‘endocarditis team’ is associated with improved survival in patients with infective endocarditis who are managed medically: findings from a before-and-after study. Open Heart. 2017;4:e000699. [PubMed: 29344368]
8. Ruch Y, Mazzucotelli JP, Lefebvre F, et al. Impact of setting up an “endocarditis team” on the management of infective endocarditis. Open Forum Infect Dis. 2019;6:ofz308. [PubMed: 31660397]
9. Andersen ND, Benrashid E, Ross AK, et al. The utility of the aortic dissection team: outcomes and insights after a decade of experience. Ann Cardiothorac Surg. 2016;5:194–201. [PubMed: 27386406]
10. Kabrhel C, Rosovsky R, Channick R, et al. A multidisciplinary pulmonary embolism response team: initial 30-month experience with a novel approach to delivery of care to patients with submassive and massive pulmonary embolism. Chest. 2016;150:384–393. [PubMed: 27006156]
11. Mahar JH, Haddadin I, Sadana D, et al. A pulmonary embolism response team (PERT) approach: initial experience from the Cleveland Clinic. J Thromb Thrombolysis. 2018;46:186–192. [PubMed: 29855780]
12. Hillis LD, Smith PK, Anderson JL, et al. 2011 ACCF/AHA guideline for coronary artery bypass graft surgery: executive summary: a report of the American College of Cardiology Foundation/American Heart Association Task Force on practice guidelines. J Am Coll Cardiol. 2011;58(24):2584–2614.
13. Levine GN, Bates ER, Blankenship JC, et al. 2011 ACCF/AHA/SCAI guideline for percutaneous coronary intervention: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions. J Am Coll Cardiol. 2011;58(24):e44–e122. [PubMed: 22070834]
14. Bonzel T, Schachinger V, Dorge H. Description of a Heart Team approach to coronary revascularization and its beneficial long-term effect on clinical events after PCI. Clin Res Cardiol. 2016;105:388–400. [PubMed: 26508415]
15. Chu D, Anastacio MM, Mulukutla SR, et al. Safety and efficacy of implementing a multidisciplinary heart team approach for revascularization in patients with complex coronary artery disease: an observational cohort pilot study. JAMA Surg. 2014;149:1109–1112. [PubMed: 25207883]
16. Luckraz H, Norell M, Buch M, James R, Cooper G. Structure and functioning of a multidisciplinary ‘Heart Team’ for patients with coronary artery disease: rationale and recommendations from a joint BCS/BCIS/SCTS Working Group. Eur J Cardiothorac Surg. 2015;48: 524–529. [PubMed: 25762394]
17. Pavlidis AN, Perera D, Karamasis GV, et al. Implementation and consistency of Heart Team decision-making in complex coronary revascularisation. Int J Cardiol. 2016;206:37–41. [PubMed: 26774827]
18. Yamasaki M, Abe K, Horikoshi R, et al. Enhanced outcomes for coronary artery disease obtained by a multidisciplinary heart team approach. Gen Thorac Cardiovasc Surg. 2019;67: 841–848. [PubMed: 30877648]
19. Doll JA, Ohman EM, Patel MR, et al. A team-based approach to patients in cardiogenic shock. Catheter Cardiovasc Interv. 2016;88:424–433. [PubMed: 26526563]

20. Nishimura RA, Otto CM, Bonow RO, et al. 2017 AHA/ACC focused update of the 2014 AHA/ACC guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on clinical practice guidelines. Circulation. 2017;135:e1159–e1195. [PubMed: 28298458]
21. Tang PT, Do DH, Li A, Boyle NG. Team management of the ventricular tachycardia patient. Arrhythm Electrophysiol Rev. 2018;7:238–246. [PubMed: 30588311]
22. Metkus TS, Baird-Zars VM, Alfonso CE, et al. Critical Care Cardiology Trials Network (CCCTN): a cohort profile. Eur Heart J Qual Care Clin Outcomes. 2022;8(7):703–708. [PubMed: 36029517]
23. Vincent JL, Moreno R, Takala J, et al. The SOFA (sepsis-related organ failure assessment) score to describe organ dysfunction/failure. On behalf of the Working Group on Sepsis-Related Problems of the European Society of Intensive Care Medicine. Intensive Care Med. 1996;22:707–710. [PubMed: 8844239]
24. Oremus M, Sharafoddini A, Morgano GP, Jin X, Xie F. A computer-assisted personal interview app in research electronic data capture for administering time trade-off surveys (REDCap): development and pretest. JMIR Form Res. 2018;2:e3. [PubMed: 30684429]
25. Gaudino M, Crea F, Massetti M, Girardi LN. Heart Team 2.0: keep your friends close and your enemy closer!. J Thorac Cardiovasc Surg. 2018;155: 874. [PubMed: 29198794]
26. Papolos AI, Kenigsberg BB, Berg DD, et al. Management and outcomes of cardiogenic shock in cardiac ICUs with versus without shock teams. J Am Coll Cardiol. 2021;78:1309–1317. [PubMed: 34556316]
27. Heidenreich P Using 30-day mortality to measure quality of heart failure care. J Am Coll Cardiol HF. 2017;5:753–755.
28. Fordyce CB, Katz JN, Alviar CL, et al. Prevention of complications in the cardiac intensive care unit: a scientific statement from the American Heart Association. Circulation. 2020;142:e379–e406. [PubMed: 33115261]
29. Matyal R, Qureshi NQ, Mufarrih SH, et al. Update: gender differences in CABG outcomes-have we bridged the gap? PLoS One. 2021;16: e0255170. [PubMed: 34525123]
30. Zwischenberger BA, Jawitz OK, Lawton JS. Coronary surgery in women: how can we improve outcomes. JTCVS Tech. 2021;10:122–128. [PubMed: 34977714]
31. Aggarwal NR, Patel HN, Mehta LS, et al. Sex differences in ischemic heart disease: advances, obstacles, and next steps. Circ Cardiovasc Qual Outcomes. 2018;11:e004437. [PubMed: 29449443]
32. Metkus TS, Suarez-Pierre A, Crawford TC, et al. Diastolic dysfunction is common and predicts outcome after cardiac surgery. J Cardiothorac Surg. 2018;13:67. [PubMed: 29903030]
33. LaPar DJ, Filardo G, Crosby IK, et al. The challenge of achieving 1% operative mortality for coronary artery bypass grafting: a multi-institution Society of Thoracic Surgeons Database analysis. J Thorac Cardiovasc Surg. 2014;148:2686–2696. [PubMed: 25152473]

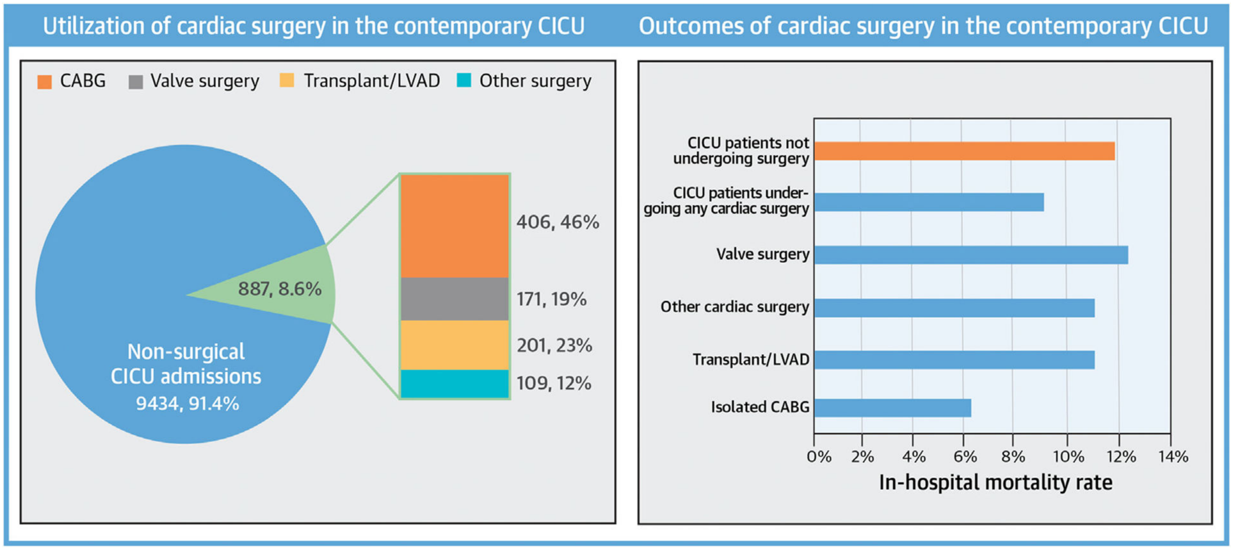
PERSPECTIVES

COMPETENCY IN MEDICAL KNOWLEDGE:

Nearly 1 in 12 contemporary CICU patients receive cardiac surgery with a comparable mortality rate to CICU patients overall.

TRANSLATIONAL OUTLOOK:

The high incidence of surgical disease in the contemporary CICU highlights the importance of ongoing multidisciplinary collaboration and quality improvement efforts between cardiac critical care clinicians and surgical teams.



CENTRAL ILLUSTRATION.

Utilization and In-Hospital Mortality Rates for CICU Patients Treated With Cardiac Surgery

CABG = coronary artery bypass grafting; CICU = cardiac intensive care unit; LVAD = left ventricular assist device

TABLE 1

Demographics and Comorbidities for CICU Patients Treated With Cardiac Surgery

	Cardiac Surgery Patients (n = 887)	CABG (n = 406)	Valve (With or Without CABG) (n = 171)	Transplant/LVAD (n = 201)	Other (Aortic Procedures, Embolectomy, Pericardial Procedures and Other) (n = 109)	Noncardiac Surgery Patients (n = 9,434)
Demographics						
Age, y	63.0 (53.0–71.0)	66.0 (59.0–73.0)	62.0 (46.0–70.0)	57.0 (44.0–64.0)	63.0 (52.0–72.0)	66.0 (56.0–76.0)
Female	249 (28.1%)	105 (25.9%)	65 (38.0%)	46 (22.9%)	33 (30.3%)	3,533 (37.4%)
White race	494 (70.2%)	207 (70.9%)	96 (69.1%)	124 (68.1%)	67 (73.6%)	5,350 (68.7%)
Weight, kg	83.0 (70.3–97.5)	81.1 (70.3–94.3)	82.7 (66.7–97.5)	87.0 (71.4–102.3)	86.1 (75.6–98.3)	81.6 (68.3–97.1)
BMI, kg/m^2	27.9 (24.6–32.0)	27.8 (25.0–31.2)	27.8 (23.4–33.2)	27.7 (24.1–32.3)	28.7 (25.0–32.7)	27.9 (24.1–32.7)
Cardiovascular comorbidities						
Current smoker	154 (17.5%)	87 (21.6%)	36 (21.2%)	12 (6.0%)	19 (17.8%)	1,590 (17.0%)
Diabetes mellitus	325 (36.6%)	194 (47.8%)	39 (22.8%)	65 (32.3%)	27 (24.8%)	3,277 (34.7%)
Hypertension	551 (62.1%)	300 (73.9%)	92 (53.8%)	90 (44.8%)	69 (63.3%)	6,169 (65.4%)
Cerebrovascular disease	72 (8.1%)	29 (7.1%)	18 (10.5%)	14 (7.0%)	11 (10.1%)	975 (10.3%)
Peripheral artery disease	82 (9.2%)	41 (10.1%)	13 (7.6%)	10 (5.0%)	18 (16.5%)	940 (10.0%)
Prior heart failure	295 (33.3%)	58 (14.3%)	49 (28.7%)	172 (85.6%)	16 (14.7%)	3,559 (37.7%)
Historical LVEF						
>50%	37 (12.9%)	10 (17.9%)	18 (38.3%)	4 (2.4%)	5 (31.3%)	970 (28.1%)
40%–<50%	19 (6.6%)	7 (12.5%)	6 (12.8%)	2 (1.2%)	4 (25.0%)	400 (11.6%)
30%–<40%	34 (11.9%)	14 (25.0%)	6 (12.8%)	12 (7.2%)	2 (12.5%)	530 (15.4%)
20%–<30%	76 (26.6%)	19 (33.9%)	12 (25.5%)	42 (25.1%)	3 (18.8%)	811 (23.5%)
<20%	120 (42.0%)	6 (10.7%)	5 (10.6%)	107 (64.1%)	2 (12.5%)	740 (21.4%)
Atrial fibrillation	167 (18.8%)	25 (6.2%)	52 (30.4%)	67 (33.3%)	23 (21.1%)	2,513 (26.6%)
Noncardiovascular comorbidities						
Chronic kidney disease	185 (20.9%)	60 (14.8%)	38 (22.2%)	71 (35.3%)	16 (14.7%)	2,325 (24.6%)
On dialysis	35 (18.9%)	19 (31.7%)	8 (21.1%)	4 (5.6%)	4 (25.0%)	560 (24.1%)
History of pulmonary disease	89 (10.0%)	32 (7.9%)	25 (14.6%)	19 (9.5%)	13 (11.9%)	1,524 (16.2%)
History of liver disease	22 (2.5%)	2 (0.5%)	5 (2.9%)	6 (3.0%)	9 (8.3%)	294 (3.1%)

Values are median (IQR) or n (%).

BMI = body mass index; CABG = coronary artery bypass grafting; CICU = cardiac intensive care unit; IQR = intraquartile range; LVAD = left ventricular assist device; LVEF = left ventricular ejection fraction.

TABLE 2

CICU Admission Indication for Patients Treated With Cardiac Surgery

	Cardiac Surgery Patients (n = 887)	CABG (n = 406)	Valve (With or Without CABG) (n = 171)	Transplant/LVAD (n = 201)	Other (Aortic Procedures, Embolectomy, Pericardial Procedures and Other) (n = 109)	Noncardiac Surgery Patients (n = 9,434)
Cardiac arrest	44 (5.0%)	20 (4.9%)	7 (4.1%)	12 (6.0%)	5 (4.6%)	933 (9.9%)
Respiratory insufficiency	221 (24.9%)	75 (18.5%)	67 (39.2%)	55 (27.4%)	24 (22.0%)	2,384 (25.3%)
Hypotension without shock	41 (4.6%)	14 (3.4%)	14 (8.2%)	5 (2.5%)	8 (7.3%)	702 (7.4%)
Cardiogenic shock	248 (28.0%)	55 (13.5%)	36 (21.1%)	140 (69.7%)	17 (15.6%)	1,528 (16.2%)
Other shock	49 (5.5%)	10 (2.5%)	25 (14.6%)	10 (5.0%)	4 (3.7%)	735 (7.8%)
Unstable arrhythmia	92 (10.4%)	24 (5.9%)	27 (15.8%)	34 (16.9%)	7 (6.4%)	1,748 (18.5%)
Need for renal replacement therapy	32 (3.6%)	11 (2.7%)	12 (7.0%)	8 (4.0%)	1 (0.9%)	349 (3.7%)
Need for ICU protocol medication or device[a]	65 (7.3%)	54 (13.3%)	4 (2.3%)	5 (2.5%)	2 (1.8%)	269 (2.9%)
Need for IV vasoactive therapy in absence of shock/hypotension	136 (15.3%)	69 (17.0%)	19 (11.1%)	22 (10.9%)	26 (23.9%)	919 (9.7%)
Need for ICU monitoring or other indication[b]	267 (30.1%)	162 (39.9%)	46 (26.9%)	12 (6%)	47 (43.1%)	3,511 (37.2%)

Values are n (%).

[a]Medication or device permitted only in an ICU setting per institutional protocol.

[b]Requirement for frequency or type of clinical monitoring above which can be provided on a ward or step down unit per institutional protocol.

CABG = coronary artery bypass grafting; CICU = cardiac intensive care unit; ICU = intensive care unit; IV = intravenous; LVAD = left ventricular assist device.

TABLE 3

Critical Care Therapeutics for CICU Patients Treated With Cardiac Surgery (Patients Could Have More Than 1 Therapy)

	Cardiac Surgery Patients (n = 887)	CABG (n = 406)	Valve (With or Without CABG) (n = 171)	Transplant/LVAD (n = 201)	Other (Aortic Procedures, Embolectomy, Pericardial Procedures and Other) (n = 109)	Noncardiac Surgery Patients (n = 9,434)
Renal replacement therapy	73 (8.2%)	21 (5.2%)	20 (11.7%)	27 (13.4%)	5 (4.6%)	559 (5.9%)
Mechanical ventilation (intubated)	317 (35.7%)	107 (26.4%)	79 (46.2%)	94 (46.8%)	37 (33.9%)	1,823 (19.3%)
Non-invasive positive pressure ventilation	75 (8.5%)	21 (5.2%)	21 (12.3%)	25 (12.4%)	8 (7.3%)	928 (9.8%)
High-flow oxygen	80 (9.0%)	25 (6.2%)	17 (9.9%)	29 (14.4%)	9 (8.3%)	640 (6.8%)
IV vasopressor, inotrope, or vasodilator	463 (52.2%)	154 (37.9%)	81 (47.4%)	172 (85.6%)	56 (51.4%)	3,491 (37.0%)
Inhaled pulmonary vasodilator	60 (6.8%)	10 (2.5%)	11 (6.4%)	37 (18.4%)	2 (1.8%)	84 (0.9%)
Any invasive hemodynamic monitoring	541 (61.0%)	181 (44.6%)	114 (66.7%)	178 (88.6%)	68 (62.4%)	2,992 (31.7%)
Pulmonary artery catheterization	274 (30.9%)	60 (14.8%)	46 (26.9%)	151 (75.1%)	17 (15.6%)	1,117 (11.8%)
Targeted temperature management	12 (1.4%)	5 (1.2%)	2 (1.2%)	3 (1.5%)	2 (1.8%)	306 (3.2%)
Temporary pacing wire	73 (8.2%)	29 (7.1%)	23 (13.5%)	18 (9.0%)	3 (2.8%)	498 (5.3%)
Mechanical circulatory support	318 (35.9%)	148 (36.5%)	28 (16.4%)	131 (65.2%)	11 (10.1%)	924 (9.8%)

Values are n (%).

CABG = coronary artery bypass grafting, CICU = cardiac intensive care unit; IV = intravenous; LVAD = left ventricular assist device.

TABLE 4

Univariable and Adjusted Association of Preoperative CICU Therapies With Postoperative Mortality

	Univariable			Adjusted for Age, Sex, Race, BMI, SOFA Score			Adjusted for Age, Sex, Race, Creatinine, Diabetes, Presence of Shock, and Presence of Acute MI		
	Odds Ratio	95% CI	*P* Value	Odds Ratio	95% CI	*P* Value	Odds Ratio	95% CI	*P* Value
Mechanical ventilation	2.20	1.39–3.48	0.0008	1.02	0.57–1.84	0.95	1.25	0.73–2.12	0.41
Noninvasive ventilation/ High-flow nasal cannula	1.22	0.65–2.29	0.53	0.84	0.42–1.67	0.61	0.89	0.45–1.73	0.73
Vasopressor/inotrope use	2.50	1.51–4.13	0.0004	1.45	0.81–2.58	0.21	1.36	0.74–2.51	0.32
Mechanical circulatory support	2.64	1.45–4.83	<0.0001	2.01	1.04–3.89	0.039	1.85	0.90–3.79	0.09
Renal replacement therapy	6.00	3.42–10.51	<0.0001	3.39	1.74–6.60	0.0003	3.06	1.61–5.81	0.0007

BMI = body mass index; CICU = cardiac intensive care unit; MI = myocardial infarction; SOFA = sequential organ failure assessment.