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Planned Cardiac Reexploration in the Intensive Care Unit Is a Safe Procedure

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Abstract

Background—Cardiac surgical reexploration is necessary in approximately 5% of all patients. However, the impact of routine, planned reexploration performed in the intensive care unit (ICU) remains poorly defined. This study evaluated postoperative outcomes after cardiac reexplorations to determine the safety and efficacy of a planned approach in the ICU.

Methods—All patients undergoing ICU cardiac reexplorations (2000 to 2011) at a single institution were stratified according to a routine, planned ICU approach to reexploration (planned) versus unplanned ICU or operating room reexploration. Patient risk and outcomes were compared by univariate and multivariate analyses.

Results—8,151 total patients underwent cardiac operations, including 267 (3.2%) reexplorations (planned ICU = 75% and unplanned ICU = 18%). Among planned ICU reexplorations, 38% of patients had an identifiable surgical bleeding source, and 60% underwent reexploration less than 12 hours after the index procedure. Unplanned ICU reexplorations had a higher Society of Thoracic Surgeons (STS) predicted mortality (5% vs 3%, $p < 0.001$) and incurred higher observed mortality (37% vs 6%, $p < 0.001$) and morbidity. Sternal wound infections were rare and were similar between groups ($p = 0.81$). Furthermore, upon STS mortality risk adjustment, unplanned ICU reexplorations were associated with significantly increased odds of mortality (OR = 26.6 [7.1, 99.7], $p < 0.001$) compared with planned ICU reexplorations.

Conclusions—Planned reexploration in the ICU is a safe procedure with acceptable mortality and morbidity and low infection rates. Unplanned reexplorations, however, increase postoperative risk and are associated with high mortality and morbidity. These data argue for coordinated, routine approaches to planned ICU reexploration to avoid delay in treatment for postoperative hemorrhage.

Mediastinal reexploration after cardiac operations remains an all-too-familiar clinical scenario for cardiac surgeons and trainees. Historical estimates suggest that reexplorations are performed after approximately 3% to 5% of all cardiac operations [1–5]. The most frequent reasons for reexploration include postoperative bleeding, cardiac tamponade,

hemodynamic instability, and cardiac arrest. Select surgical series have been performed in the past with varying reports of outcomes after mediastinal reexplorations [3, 5–7]. Furthermore, previous series have suggested that cardiac reexploration outside the operating room may be associated with increased mediastinal infection rates and prolonged intensive care unit (ICU) and hospital lengths of stay [8]. Many former reports, however, are limited by outdated historical analyses, small sample sizes, and lack of risk adjustment in reported outcomes.

At our institution, we have adopted a belief that mediastinal reexplorations after cardiac operations for continued bleeding, or washout after bleeding, can be performed outside the operating room, and in the ICU, without increased risk to the patient when performed in a controlled and coordinated fashion. This approach potentially avoids delays going to the operating room. Thus, at our institution, reexplorations are routinely performed in the ICU, and we define a planned reexploration as one occurring in the setting of hemodynamic stability for continued hemorrhage, washout after bleeding, or mediastinal exploration after rescued cardiac arrest. Alternatively, an unplanned reexploration is one performed most often in an urgent or emergent setting for hemodynamic instability caused by cardiac tamponade or cardiac arrest. Although we believe that our approach to reexploration confers certain clinical advantages, ICU reexploration may be criticized on the basis of skepticism about the lack of a sterile surgical environment. However, few published reports exist to either challenge or support the safety and efficacy of ICU reexplorations after cardiac operations. Further clarification of this gap in current clinical knowledge remains essential to identify best clinical practice patterns for patients undergoing cardiac operations.

The purpose of this study was to evaluate outcomes after postoperative mediastinal reexplorations in the ICU to determine the safety and efficacy of a planned, coordinated surgical approach. We tested the null hypothesis that postoperative outcomes would not be significantly different among patients undergoing planned versus unplanned ICU reexplorations.

Patients and Methods

Patients

This study was approved by the University of Virginia Institutional Review Board, including an institutional waiver for the need to obtain patient consent. All patients undergoing cardiac operations at the University of Virginia were entered prospectively into a certified institutional Society of Thoracic Surgeons (STS) Adult Cardiac Surgery database. We retrospectively reviewed all adult (age >18 years) patients undergoing cardiac operations from January 2000 to December 2011. Patients undergoing mediastinal reexplorations in the ICU were further selected to define the final study cohort. Patient records were subsequently stratified based on reexploration status in the ICU: planned versus unplanned reexploration.

Patient demographics, preoperative risk factors, operative features, and postoperative outcomes were compared between study groups. Established STS definitions were used for all preoperative variables, postoperative adverse events including deep sternal wound infection (DSWI), and outcomes [9]. All patient outcomes of interest were established a

priori before data collection. Operative mortality was defined as patient deaths occurring before hospital discharge or within 30 days of operation.

Reexploration Technique in the Intensive Care Unit

All mediastinal reexplorations performed in the ICU use a standardized surgical approach consistent with standard operating room procedure and protocol. Patients undergo reexplorations under general anesthesia in coordination with anesthesia and cardiac critical care services. All planned ICU reexplorations are performed in coordination with our institution's anesthesia department. For the large majority of cases, an anesthesia attending physician is involved during the reexploration. In a minority of cases, senior anesthesia residents may participate in the reexploration with an anesthesia attending immediately available. Each patient is continuously monitored, including heart rate and rhythm, blood pressure, and core body temperature. A surgical time-out and preoperative planning procedure is performed before the operation is begun. All patients are prepped and draped according to a sterile technique identical with those used for all index cardiac operations and for reexplorations performed in the operating room. We use standard surgical lighting, which is available in each ICU room, a predefined set of sterile surgical instruments that have been selected for chest reexplorations, standard electrocautery and surgical suction, and trained operating room and ICU technical and nursing staff for surgical assistance. Patients are administered prophylactic antibiotics before reexploration in a manner similar to procedures performed in the operating room. At the conclusion of each reexploration, all surgical sponge, needle, and instrument counts are performed and confirmed. Surgical wounds are dressed in a sterile fashion and remain in place for 48 hours to minimize the likelihood of surgical wound infections. An operative note is dictated for the patient record.

Statistical Analysis

The primary outcome of interest was the risk-adjusted impact of unplanned versus planned ICU reexploration on operative mortality. Secondary outcomes of interest included differences in unadjusted postoperative morbidity, mortality, and resource utilization between study groups. All study group comparisons were unpaired. Categorical variables were compared with either Pearson's χ^2 test or Fisher's exact test, and continuous variables were compared with Student's t test for normally distributed data or the Wilcoxon rank sum test for non-normally distributed data where appropriate.

To further account for potential confounding in patient risk profiles, binary multivariable logistic regression was used to estimate the risk-adjusted association between the performance of an unplanned mediastinal reexploration and the likelihood of mortality. This estimated association was adjusted for baseline patient risk through the inclusion of the STS Predicted Risk of Mortality (PROM) score as a covariate in the regression model. Logistic regression model discrimination between survivors and decedents was assessed by the model's c statistic. The amount of variance in the response variable explained by the model was assessed by Nagelkerke Pseudo R^2 values, and the Hosmer-Lemeshow test was used to assess model calibration across deciles of observed and predicted risk.

All categorical variables were expressed as a percentage of the group of origin, and continuous variables were expressed as either means $\pm$ standard deviation (SD) or median (interquartile range). Odds ratios (OR) with a 95% confidence interval (CI) were used to report the results of the multivariable logistic regression model. All reported p values were considered statistically significant for values <0.05 . Data analysis was performed with R statistical software, version 2.12.1 (The R Foundation for Statistical Computing, <http://www.R-project.org>).

Results

Comparison of Patient Characteristics and Risk Factors

A total of 8,151 patients underwent cardiac operations at the University of Virginia during the study period, including 267 patients (3.2%) who underwent postoperative mediastinal reexplorations. Within this study cohort, 201 patients (75%) underwent routine, planned ICU reexplorations, and a total of 47 patients (18%) underwent urgent or emergent unplanned reexplorations. No patients who underwent ICU reexploration required cardiopulmonary bypass support to address their problems. Furthermore, none of the patients who underwent ICU reexplorations were subsequently transferred to the operating room for further reexploration. Reexplorations in the operating room occurred in 7% of patients ($n = 19$) during the study period.

Table 1 compares the frequency of patient demographics and patient risk profiles for both surgical populations. Overall, baseline patient risk was similar between study groups. The average patient age was slightly higher among those undergoing planned reexplorations (63.6 years vs 59.9 years) ($p = 0.09$), and a trend toward unplanned reexplorations was observed among female patients (42.4% vs 29.5%) ($p = 0.05$). Both study cohorts had similar frequencies of preoperative hypertension, diabetes, history of endocarditis, stroke, and heart failure. Patients undergoing unplanned reexplorations, however, had a higher frequency of preoperative renal failure (19.7% vs 8.5%) ($p = 0.04$). As a result, these incremental differences resulted in statistically similar STS predictive risk indices (STS PROM, $p = 0.71$ and STS Predicted Risk of Reoperation, $p = 0.54$) for both study populations. Transportation to the ICU with open chests occurred in 3.6% of patients ($n = 9$) who underwent planned ($n = 6$, 3.0%) versus unplanned ($n = 3$, 6.8%) ($p = 0.38$) ICU reexplorations.

Table 2 demonstrates the differences in operative features for index procedures occurring before mediastinal reexploration. Overall, patients underwent a high proportion of high-risk, complex procedures. Among procedure types, isolated CABG operations occurred in approximately 25% of patients, and isolated aortic valve replacement was performed in approximately 17% of cases. However, the category “other” procedure was the most frequent procedure type recorded for patients, typically including high-risk, complex operations such as double valves, ventricular assist device implantation, aortic operations, and operations that include arrhythmia ablation. Emergent operations were performed in approximately 10% of patients, and more than half of patients underwent cardiac reoperations (ie, operations after a prior sternotomy) before mediastinal reexploration.

Further differences related to mediastinal reexploration were observed between study cohorts. Overall, the most frequent indication for reexploration was persistent postoperative hemorrhage or mediastinal washout after excessive bleeding (57%, $n = 153$), followed by reexploration after rescue from cardiac arrest (11%, $n = 22$), tamponade with hemodynamic instability (2.9%, $n = 8$), and cardiac arrest (30%, $n = 80$). Among patients undergoing planned reexplorations, 76% underwent reexplorations for postoperative bleeding, and an identifiable bleeding source was identified in 38% of cases. Reexploration within 12 hours was performed in 60% of all cases. Unplanned ICU reexplorations were performed for cardiac tamponade (48%) or for mediastinal washout (52%).

Impact of Mediastinal ICU Reexploration on Postoperative Morbidity, Mortality, and Resource Utilization

Table 3 displays the incidence of postoperative events and adverse events for all patients undergoing mediastinal reexplorations within the ICU. The overall rate of postoperative DSWI was 1.9%. Select differences in the incidence of postoperative events and adverse events were also observed between reexploration study groups. Planned reexplorations were associated with reduced morbidity and mortality, including a lower incidence of perioperative myocardial infarction, postoperative renal failure, new-onset hemodialysis, prolonged ventilation, and pneumonia (all $p < 0.001$). Operative mortality was 5.5% among planned reexploration patients compared with 36.4% for unplanned reexploration patients ($p < 0.001$). No significant differences in DSWI rates ($p = 0.81$) or median ICU length of stay ($p = 0.10$) (Fig 1A) or postoperative length of stay ($p = 0.61$) (Fig 1B) were observed between study groups. After adjustment for preoperative patient risk, unplanned ICU reexploration was associated with significantly increased odds of operative mortality (OR = 26.6 [7.1, 99.7], $p < 0.001$). The statistical model achieved adequate discrimination with a c statistic of 0.78 and described 43% of the variance existing in each response variable (ie, Nagelkerke Pseudo $R^2 = 0.43$). Model calibration was acceptable with Hosmer-Lemeshow $p = 0.16$.

Further comparisons of planned ICU reexplorations versus explorations performed in the operating room revealed no statistically significant differences in patient outcomes despite higher incidences of postoperative morbidity and mortality among patients undergoing operating room reexplorations. Specifically, the incidences of several measures of postoperative morbidity were similar between cohorts: DSWI (0.0% vs 2.0%), pneumonia (21.1% vs 10.4%), prolonged ventilation (63.2% vs 48.3%), perioperative myocardial infarction (10.5% vs 0.5%), renal failure (26.3% vs 12.9%), and new-onset hemodialysis (15.8% vs 6.0%) (all $p > 0.05$). Similarly, no significant differences in operative mortality were detected between planned ICU reexplorations and reexplorations performed in the operating room (10.5% vs 5.5%) ($p = 0.70$).

Comment

This study reports the clinical impact of routine mediastinal reexplorations in the ICU setting after cardiac operations in adults. Our report of 267 patients undergoing cardiac operations suggests that performance of planned ICU reexplorations in the setting of

hemodynamic stability does not confer increased patient risk and is superior to reexplorations performed in an unplanned setting of hemodynamic instability with cardiac tamponade or cardiac arrest. The performance of routine ICU reexplorations was not associated with increased risk of mortality or, perhaps more importantly, DSWI. Furthermore, this practice had no significant impact on either ICU or postoperative length of stay. Overall, these results expand on a scarcity of existing data that have addressed postoperative cardiac reexplorations, and they highlight the safety and efficacy of a routine approach to mediastinal reexploration in the post-cardiac operation ICU setting.

Little research has been conducted over the past few decades to determine the impact of routine mediastinal reexplorations in the ICU after cardiac operations. However, these data are essential to provide clinical direction and identify best-practices techniques to improve patient outcomes in the most cost-effective manner. The available literature addressing this gap in knowledge represents relatively small, single-institution series, many with significant methodologic issues related to potential confounding and bias. As a result, the debate regarding the most efficacious strategy for mediastinal reexploration for hemodynamically stable patients after cardiac operations remains unsettled.

The principal findings of the present study are consistent with those of previous reports, and they corroborate our belief that planned ICU reexplorations can be performed safely without increased patient risk. In this 12-year surgical experience, the 3.2% mediastinal reexploration rate after cardiac operations for bleeding, cardiac tamponade, or cardiac arrest is comparable to other series that have reported reexploration rates of 3% to 5% [1–5, 10]. The rather low incidence of postoperative adverse events in patients undergoing planned cardiac reexplorations in the present series further bolsters its proposed efficacy. Perhaps the most worrisome adverse event after any cardiac reexploration or reoperation concerns the development of DSWI. Occurring after approximately 1% to 5% of all cardiac operations [5, 10, 11], this adverse event has the potential to confer significant postoperative morbidity to the patients and to require extensive utilization of medical and surgical resources. Previous reports have identified various risk factors for DSWI, including patient body mass index (>40), diabetes, prior smoking history, chronic lung disease, preoperative renal failure and hemodialysis, postoperative hemorrhage, lengthy operations and cardiopulmonary bypass times, internal thoracic artery harvesting, intraaortic balloon pump use, and early postoperative mediastinal reexploration [5, 11–13]. For many clinicians, the principal concern surrounding the performance of ICU reexplorations is a lack of sterile environment and an increased potential for avoidable sternal wound infections. In our series, however, we demonstrate that DSWIs were not increased among patients undergoing ICU mediastinal reexplorations. In fact, the 1.9% overall rate of DSWI among patients undergoing reexplorations in this series compares favorably with those in existing reports. The low rate of DSWI in this series likely reflects the results of our routine approach to ICU reexploration, including early recognition of patients requiring reexploration to avoid chest compressions, use of aseptic techniques for patient skin and wound preparation identical with those used in the operating room, use of trained operating room staff and nurses familiar with sterile technique, and the use of sterile surgical instruments, careful sternal closure, and consistent monitoring of patient core body temperature and perfusion to optimize sternal wound healing.

Operative mortality and the incidence of other major adverse events in this series are consistent with predicted surgical risk and other reported surgical series of high-risk surgical patients and those undergoing mediastinal reexploration. The 5.5% operative mortality rate among patients with expected mortality of 3% who underwent planned ICU reexplorations in this series compares favorably with rates in former surgical series describing reexplorations after cardiac operations in both operating room and ICU settings [1, 3, 5, 14]. In one report of patients undergoing ICU reexplorations, mortality was 6.7% among a patient population similar to those undergoing planned reexplorations in our study [1]. The increased mortality and morbidity reported in the present series and former series for patients requiring postoperative reexplorations are largely due to sequelae from excessive bleeding, increased transfusion requirements, impaired oxygen delivery, and hemodynamic consequences, including postoperative renal failure, prolonged mechanical ventilation and perhaps a requirement for postoperative mechanical circulatory support (ie, intra-aortic balloon pump or extracorporeal membrane oxygenation).

In this series, it is critical to emphasize our approach to planned and unplanned ICU reexplorations after cardiac operations. As previously described, inasmuch as it has become our routine to perform mediastinal reexplorations after cardiac operations in the ICU, we consider planned re-explorations to be those occurring in patients who primarily experience persistent bleeding or excessive bleeding requiring washout and who remain hemodynamically stable. In the current series, this situation occurred in the large majority of patients who underwent planned reexplorations. Other planned reexplorations occurred in patients who underwent exploration because of bleeding when concern existed for impending cardiac tamponade before hemodynamic instability (13%) or after rescue from cardiac arrest when the bleeding was believed to be the primary cause (11%). An important distinction between these scenarios and those for unplanned reexplorations is required because our routine, coordinated, multidisciplinary approach to reexploration is often not completely used for urgent and emergent clinical scenarios (cardiac tamponade with hemodynamic instability and cardiac arrest) requiring unplanned ICU reexplorations. In our practice, the decision for planned mediastinal reexploration is based on the clinical judgment of a senior cardiac surgical resident in consultation with an attending surgeon, and we do not adhere to previously defined or strict clinical criteria (eg, chest tube output, transfusion threshold) to guide these decisions. We also believe that early recognition and intervention for patients requiring mediastinal reexploration is essential for success. Our goal is to perform reexploration on at-risk patients within 12 hours, which occurred in a majority of cases (60%) in this series. Finally, for those patients in whom persistent bleeding without an identifiable bleeding source is encountered at reexploration, our approach is to pack the chest and leave it open while optimizing medical management, coagulation profile, core body temperature, and metabolic profile until bleeding is controlled.

Reexploration in the ICU is not ideal for all patients. Certain clinical scenarios where a controlled and safe ICU mediastinal reexploration is not possible are better addressed in the operating room. In our experience, we prefer to perform mediastinal reexplorations in the operating room for patients when we believe the need for cardiopulmonary bypass is highly likely. Also, patients who may require difficult or alternative cardiopulmonary cannulation, those with extensive mediastinal adhesions from prior sternotomy or mediastinal infections,

and those with a high risk for potential injury or catastrophe upon reexploration or reentry are transported to the operating room for reexploration. During the current study period, reexplorations in the operating room for such scenarios were performed in 7.2% of patients, requiring repeated sternotomy for bleeding. Interestingly, patients undergoing reexplorations in the operating room accrued a higher incidence of postoperative morbidity and mortality than did those undergoing planned ICU reexplorations; however, owing to the relatively small sample of these patients, these differences did not achieve statistical significance. Larger sample comparisons of ICU versus operating room reexplorations are needed to enable further characterization of the perceived benefit of early, planned ICU reexplorations.

The reported results have significant clinical implications, and the routine performance of planned ICU reexploration, as described herein, has the potential to confer important clinical benefits for patients undergoing cardiac operations. We remain strong advocates for the performance of timely, planned, mediastinal reexploration after cardiac operations in a controlled setting because it allows for the control of bleeding and avoidance of cardiac tamponade with hemodynamic instability. As a result, these efforts have the great potential benefit to avoid chest compressions after a recent sternotomy during cardiopulmonary resuscitation after cardiac arrest. Planned reexploration also has the potential to avoid excessive blood product transfusion, which may further avoid the negative impact of transfusion-related acute lung injury, fluid sequestration, and associated prolonged mechanical ventilation. Planned ICU reexploration also has the potential to avoid delay in care for patients with impending cardiac tamponade and the potential negative impact on patient outcomes resulting from patient transport to the operating room and coordination of operating room setup and staffing. Thus, improved resource utilization has significant implications for potential cost reductions and the delivery of cost-effective cardiac surgical care. However, perhaps the most important advantage of a timely, planned approach to ICU reexplorations is the reduction of reentry injuries to prior bypass grafts or prosthetic valve disruption caused by reexplorations occurring in the urgent or emergent setting resulting from delay in care as a function of operating room resources and staffing when postoperative mediastinal reexploration is required.

The reported results have limitations. The retrospective study design is subject to inherent selection bias. A single-institution experience may not be generalizable to other institutions with differing ICU and operating room resources. Although they are clinically advantageous, the low frequency of ICU reexplorations in this study sample (3.2%) limits robust statistical modeling efforts and empiric data analysis; however, this is a fundamental limitation of other smaller series that has been improved upon in our analyses. Nevertheless, future larger-cohort analyses will add increased statistical power to reported differences in patient outcomes. Finally, the present results are limited to short-term outcomes and do not provide perspective on the long-term effects of postoperative reexploration. Nevertheless, to our knowledge, this study represents one of the largest cardiac surgical series to examine the risk-adjusted safety and efficacy of routine, ICU mediastinal reexplorations and provides further insight into a principal gap in clinical knowledge.

It is concluded that on the basis of the present results, a routine, planned approach to cardiac surgical reexplorations in the ICU setting is safe, with acceptable mortality, morbidity, and

low infection rates. Planned reexplorations should be considered for patients with postoperative hemorrhage and hemodynamic stability in a timely fashion to avoid the adverse events of cardiac tamponade, excessive blood product transfusion, and external chest compressions. Unplanned reexplorations for cardiac tamponade with hemodynamic instability or cardiac arrest, however, increase postoperative risk and are associated with high mortality and morbidity. These data argue for well-coordinated, routine approaches to planned ICU reexploration to avoid delay in treatment for postoperative hemorrhage after cardiac operations during a wait to perform reexplorations in the operating room. An ICU-based approach to early mediastinal reexploration has the potential to greatly improve hospital and operating room resource utilization and costs.

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Fig 1.

(A) Comparison of median intensive care unit (ICU) length of stay (LOS) (hours) for patients undergoing planned versus unplanned ICU reexplorations ($p = 0.10$). (B) Comparison of median postoperative LOS (days) for patients undergoing planned versus unplanned ICU reexplorations ($p = 0.61$).

Table 1

Patient Demographics and Risk Factors for Patients Undergoing Planned Versus Unplanned ICU Reexplorations

Factor	Planned (n = 201)	Unplanned (n = 47)	p
Patient age, y	63.6 ± 17.2	59.9 ± 16.8	0.09
Female	29.5%	42.4%	0.05
Hypertension	66.7%	66.7%	0.37
Diabetes	28.4%	28.8%	0.21
Endocarditis	3.0%	4.5%	0.54
Stroke	9.5%	13.6%	0.34
Renal failure	8.5%	19.7%	0.04
Hemodialysis	4.0%	4.5%	0.84
Heart failure	41.8%	53.0%	0.11
STS PROM, % (IQR)	3.0 (1.0, 11.0)	5.0 (2.0, 14.0)	0.71
STS predicted risk of reoperation, % (IQR)	6.0 (4.0, 11.0)	7.0 (4.0, 10.0)	0.54

ICU = intensive care unit; IQR = interquartile range; STS PROM = Society of Thoracic Surgeons Predicted Risk of Mortality.

Table 2

Operative Features for Patients Undergoing Planned Versus Unplanned ICU Reexplorations

Factor	Planned, % (n = 201)	Unplanned, % (n = 47)	<i>p</i>
Procedure type			0.53
CABG only	25.9	25.8	
AVR	18.9	16.7	
MV replacement	4.0	6.1	
MV repair	2.5	1.5	
MV repair + CABG	1.0	4.5	
Other	45.3	40.9	
Status			0.10
Elective	49.8	33.3	
Urgent	41.3	51.5	
Emergent	8.5	13.6	
Reoperation	50.2	66.6	0.51

AVR = aortic valve replacement; CABG = coronary artery bypass grafting; ICU = intensive care unit; MV = mitral valve.

Table 3

Comparison of Unadjusted Postoperative Outcomes for Patients Undergoing Planned Versus Unplanned ICU Reexplorations

Factor	Planned, % (n = 201)	Unplanned, % (n = 47)	p
Stroke	8.5	16.7	0.06
Deep sternal wound infection	2.0	1.5	0.81
ECMO	1.0	18.2	<0.001
IABP	10.9	42.4	<0.001
Perioperative MI	0.5	4.5	0.02
Renal failure	12.9	34.8	<0.001
New-onset hemodialysis	6.0	24.2	<0.001
Prolonged ventilation	48.3	68.2	0.01
Pneumonia	10.4	22.7	0.01
Cardiac arrest	8.5	45.5	<0.001
Mortality	5.5	36.4	<0.001

ECMO = extracorporeal membrane oxygenation; IABP = intraaortic balloon pump; ICU = intensive care unit; MI = myocardial infarction.