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On-Hours Compared to Off-Hours Pediatric Extracorporeal Life Support Initiation in the United States Between 2009 and 2018—An Analysis of the Extracorporeal Life Support Organization Registry

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OBJECTIVES: We aimed to investigate whether there are differences in outcome for pediatric patients when extracorporeal life support (ECLS) is initiated on-hours compared with off-hours.

DESIGN: Retrospective cohort study.

SETTING: Ten-year period (2009–2018) in United States centers, from the Extracorporeal Life Support Organization registry.

PATIENTS: Pediatric (>30 d and <18 yr old) patients undergoing venovenous and venoarterial ECLS.

INTERVENTIONS: The primary predictor was on versus off-hours cannulation. On-hours were defined as 0700–1859 from Monday to Friday. Off-hours were defined as 1900–0659 from Monday to Thursday or 1900 Friday to 0659 Monday or any time during a United States national holiday. The primary outcome was inhospital mortality. The secondary outcomes were complications related to ECLS and length of hospital stay.

MEASUREMENTS AND MAIN RESULTS: In a cohort of 9,400 patients, 4,331 (46.1%) were cannulated on-hours and 5,069 (53.9%) off-hours. In the off-hours group, 2,220/5,069 patients died (44.0%) versus 1,894/4,331 (44.1%) in the on-hours group ($p = 0.93$). Hemorrhagic complications were lower in the off-hours group versus the on-hours group (hemorrhagic 18.4% vs 21.0%; $p = 0.002$). After adjusting for patient complexity and other confounders, there were no differences between the groups in mortality (odds ratio [OR], 0.95; 95% CI, 0.85–1.07; $p = 0.41$) or any complications (OR, 1.02; 95% CI, 0.89–1.17; $p = 0.75$).

CONCLUSIONS: Survival and complication rates are similar for pediatric patients when ECLS is initiated on-hours compared with off-hours. This finding suggests that, in aggregate, the current pediatric ECLS infrastructure in the United States provides adequate capabilities for the initiation of ECLS across all hours of the day.

KEY WORDS: extracorporeal membrane oxygenation; extracorporeal life support; off-hours; on-hours; pediatrics; timing

The delivery of tertiary and quaternary pediatric critical care services, including extracorporeal life support (ECLS), requires continuous care throughout all hours of the day. Essential resources include the immediate availability of multidisciplinary medical and surgical teams (1). However, staffing models vary between centers, and most have fewer in-house resources during night and weekend (off) hours compared with weekday (on) hours (2, 3). Limited evidence indicates that outcomes are worse for patients admitted to

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DOI: 10.1097/CCE.0000000000000698

the PICU during nighttime hours, when controlling for severity of illness and comorbidities, but this finding has not been consistent across studies (4–8).

The planned initiation of ECLS in pediatric patients is a rare, complex, and high-risk event that requires significant multidisciplinary resources. In most cases, ECLS is initiated after the failure of escalating standard supportive therapies, and thus, cannulation for ECLS is usually not an elective procedure per se. As such, potential differences between on- and off-hours outcomes may be exacerbated in pediatric patients placed on ECLS.

Unplanned ECLS occurs when it is deployed during resuscitation after cardiopulmonary arrest (extracorporeal cardiopulmonary resuscitation [eCPR]). Worse outcomes following cardiac arrest, including eCPR, that occur off-hours compared with on-hours have been described in adult and pediatric studies (9–11). However, the multifactorial nature of eCPR confounds the attribution of these differences specifically to ECLS. Outside of eCPR, limited data from small studies of combined neonatal and pediatric populations have reported conflicting results on the impact of on-hours compared with off-hours ECLS cannulation on outcomes (12, 13).

Therefore, it remains unknown whether there are differences in outcome for pediatric ECLS-initiated on-hours compared with off-hours. In this study, we analyzed a recent 10-year period from the Extracorporeal Life Support Organization (ELSO) Registry in order to determine associations between mortality and complication rates when initiation occurred on-hours compared with off-hours, in pediatric patients undergoing venovenous (VV) and venoarterial (VA) ECLS in the United States. We hypothesize that children cannulated onto ECLS during the off-hour period will have increased mortality, more complications, longer ECLS runs, and prolonged hospital stays.

MATERIALS AND METHODS

This is a retrospective multicenter study using data from the ELSO registry. Inclusion criteria were pediatric patients more than 30 days and less than 18 years old who required ECLS in U.S. centers from 2009 to 2018 (10 yr). Additionally, centers with less than 10 runs over the study periods were excluded from the analysis (253 observations). If several runs per patient were present, the first run was used.

Our primary predictor was on versus off-hours cannulation. On-hours were defined as 0700–1859 from Monday to Friday. Off-hours were defined as 1900–0659 from Monday to Thursday or 1900 Friday to 0659 Monday or any time during a U.S. national holiday (0700–0659 the following day).

The primary outcome was inhospital mortality. The secondary outcomes were complications related to ECLS and length of hospital stay. Complications were grouped into the following categories: mechanical, hemorrhagic, neurologic, renal, cardiovascular, pulmonary, metabolic, and limb-related (details for specific complication for each group can be found in **Supplemental Table 1**, http://links.lww.com/CCX/A994, and the **ELSO Case Report Form**, http://links.lww.com/CCX/A994). Complications were coded as present or absent irrespective of when they occurred during the ECLS run.

Patient, pre-ECLS, and ECLS characteristics were compared between on-hours and off-hours cannulations using descriptive statistics. Binary and categorical predictors are presented as percentages were compared using the chi-square test. Continuous predictors are presented as median and interquartile range (IQR) and were compared using the rank-sum test.

We used the Pediatric Complex Chronic Conditions (CCC) Classification System version 2 (CCC v2) to adjust for case mix (14). The CCC v2 uses a comprehensive set of codes available from the *International Classification of Diseases,* 9th Edition and *International Classification of Diseases,* 10th Edition (ICD-10) to define nine CCCs (cardiovascular, respiratory, neuromuscular, renal, gastrointestinal, hematologic or immunologic, metabolic, other congenital or genetic, and malignancy).

Because it is known that both treatment and outcomes may vary across centers, our analytic approach to evaluate the relationship between on- and off-hours cannulations and outcomes accommodated for confounding by center using logistic regression and approaches clustering on the center level (15). The cluster effect was fitted using the "cluster" option in the STATA package (StataCorp LP, College Station, TX). This implies that the cluster (hospital) effect is considered to be a random effect. Results were adjusted for age, sex, race, ECLS type (pulmonary, cardiac, and eCPR), time to intubation, time from intubation to ECLS, number of CCC, pre-ECLS blood pressure, pH and Po_2, number of vasopressors used (dobutamine, dopamine, norepinephrine, epinephrine, milrinone, and levosimendan), and use of cardiopulmonary bypass within 24 hours of ECLS initiation. Both unadjusted and adjusted odds ratios (OR) and 95% CIs are presented using logistic models that were developed considering hospital as a random effect, which takes into account the intragroup correlation (16).

For hospital length of stay (LOS), competing risk regression analysis was used. Competing risk analysis refers to a special type of survival analysis that aims to correctly estimate marginal probability of an event in the presence of competing events. Traditional methods to describe survival process, such Kaplan-Meier product-limit method, are not designed to accommodate the competing nature of multiple causes to the same event; therefore, they tend to produce inaccurate estimates when analyzing the marginal probability for cause-specific events. We fitted a competing risk model for LOS with inhospital mortality as the competing risk. The model included indicator variables for centers and other covariates as noted above. Competing risk regression calculates subhazard ratios (SHRs) for discharge comparing off-hour with on-hour cannulation, that is, an SHR below 1 indicates a longer hospital stay and a decreased likelihood of discharge over time.

To investigate a potential difference in the strength of the association of on- and off-hour cannulations and outcomes, we performed an exploratory analysis to screen for interactions between mode (VV vs VA) and primary predictor and type (pulmonary, cardiac, and eCPR) and primary predictor with regard to outcomes. A significant interaction term indicates that the strength of the association between predictor and outcome is different for the respective subgroups. For example, if the interaction term for VV versus VA ECLS and primary predictor is significant for a certain outcome, the OR for the primary predictor and the outcome needs to be reported separately for each subgroup (i.e., VV and VA ECLS).

To take into consideration multiple comparison when assessing the eight different complications groups, we used a Bonferroni correction with a significant p value of less than 0.006 corresponding to a CI of 99.4%. For interaction terms, we considered a p value of less than 0.1 as significant. For the rest of the analysis, we considered a p value of less than 0.05 as significant.

Missing data were frequent (>10%) for some variables; however, the mechanism of missingness was at random. We present the multivariable results as complete case series and performed sensitivity analyses by excluding the variables with more than 10% missing data from our multivariable analyses.

All analyses were performed using Stata (Version 16).

The University of California, San Francisco Institutional Review Board approved the study based on established criteria for fully deidentified data and waived the need for full committee review (February 24, 2020).

RESULTS

We identified a total of 9,400 patients: 4,331 (46.1%) were cannulated during on-hours, and 5,069 (53.9%) were cannulated off-hours (**Fig. 1**). For the entire population, the median age was 492 days (IQR, 127–2,902 d), and 4,432 patients (47.2%) were female.

Table 1 shows patient, pre-ECLS, and ECLS run characteristics between patients cannulated on- and off-hours. Patients cannulated off-hours were older (539 d [IQR, 135–3,242 d] vs 448 d [IQR, 118–2,473 d]; $p < 0.001$). The distribution of CCC was different between the two groups with a higher percentage of 0 CCC in the off-hours group (45.3% vs 40.6%; $p < 0.001$). The off-hours group had a shorter time from admission to intubation (6.5 hr; IQR, 0–86 hr vs 9 hr; IQR, 0–126 hr; $p < 0.001$) but a similar time from intubation to ECLS cannulation (17 hr; IQR, 5–72 hr vs 17 hr; IQR, 5–85 hr; $p = 0.6$), and a lower pH before

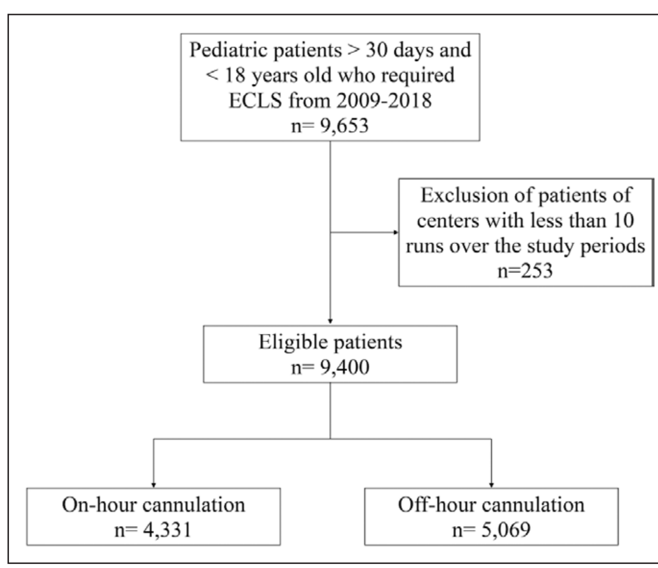

Figure 1. Study population.

TABLE 1.
Patient, Preextracorporeal Life Support, and Extracorporeal Life Support Run Characteristics

Patient Characteristics	On-Hours ($n = 4,331$)	Off-Hours ($n = 5,069$)	p
Female sex, n (%)	2,068 (48.2)	2,364 (48.0)	0.81
Age, d, median (IQR)	448 (118–2,473)	539 (135–3,242)	**< 0.001**
Race, n (%)			
White	2,109 (48.7)	2,459 (48.5)	0.31
Black	942 (21.8)	1,113 (22.0)	
Asian	140 (3.2)	144 (2.8)	
Hispanic	726 (16.8)	813(16.0)	
Other	414 (9.6)	540 (10.7)	
Number of complex chronic conditions, n (%)			
0	1,758 (40.6)	2,394 (45.3)	**< 0.001**
1	1,889 (43.6)	2,071 (40.9)	
2	490 (11.3)	515 (10.2)	
3	148 (3.4)	138 (2.7)	
4	34 (0.8)	33 (0.7)	
> 4	12 (0.3)	18 (0.4)	
Time from admission to intubation, hr, median (IQR)	9 (0–126)	6.5 (0–86)	**< 0.001**
Time from intubation to ECLS, hr, median (IQR)	17 (5–89)	17 (5–72)	0.64
Pre-ECLS Characteristics	On-Hours ($n = 4,331$)	Off-Hours ($n = 5,069$)	p
Systolic blood pressure, median (IQR)	70 (52–89)	69 (52–89)	0.62
pH, median (IQR)	7.21 (7.08–7.33)	7.19 (7.06–7.31)	**< 0.001**
P_{CO_2}, median (IQR)	56 (44–79)	58 (43–81)	0.36
P_{O_2}, median (IQR)	55 (39–88)	55 (38–85)	0.21
Number of vasopressors and inotropes,[a] n (%)			
0	1,601 (37.0)	1,782 (35.2)	0.058
1	1,135 (26.2)	1,309 (25.8)	
2	1,040 (24.0)	1,337 (26.4)	
≥ 3	555 (12.8)	641 (12.7)	
Cardiopulmonary bypass within 24 hr prior to initiation of ECLS	627 (14.5)	431 (8.5)	**< 0.001**
ECLS Run Characteristics	On-Hours ($n = 4,331$)	Off-Hours ($n = 5,069$)	p
Mode, n (%)			
Venovenous	936 (21.8)	1,154 (23.0)	0.15
Venoarterial	3,358 (78.2)	3,854 (77.0)	
Support type, n (%)			
Pulmonary	1,563 (36.1)	1,951 (38.5)	**0.001**
Cardiac	1,775 (40.9)	1,892 (37.3)	
ECPR	993 (22.9)	1,226 (24.2)	

ECLS = extracorporeal life support, ECPR = extracorporeal cardiopulmonary resuscitation; IQR = interquartile range.
[a]Dobutamine, dopamine, norepinephrine, epinephrine, milrinone, and levosimendan.
Boldface values indicate values <0.05.

going on ECLS (7.19; IQR, 7.06–7.31 vs 7.21; IQR, 7.08–7.33; $p < 0.001$). **Supplemental Table 2** (http://links.lww.com/CCX/A994) shows the frequency of missing data for our assessed covariates.

In the off-hours group, 2,220/5,069 patients died (44.0%) versus 1,894/4,331 (44.1%) in the on-hours group ($p = 0.93$). Patients cannulated during off-hours had fewer complications (58.3% without any complications) than the on-hours group (55.6% without any complications; $p = 0.005$). Similarly, patients cannulated off-hours had a shorter LOS with 41 days (IQR, 24–74 d) versus 45 days (IQR, 26–78 d) in patients cannulated during on-hours ($p = 0.018$; **Table 2**).

After Bonferroni corrections, the crude association between on- or off-hours cannulations and any specific complication was significant for hemorrhagic complications only, with fewer hemorrhagic complications in the off-hour group (18.4% vs 21.0%; $p = 0.002$; Table 2).

After adjusting for patient complexity and other confounders, the adjusted OR between on- and off-hours cannulations and mortality was 0.95 (95% CI, 0.85–1.07; $p = 0.41$). Similarly, the adjusted OR between our primary predictor and any complications was not significant with 1.02 (95% CI, 0.89–1.27; $p = 0.75$). The SHR for LOS was 1.05 (95% CI, 0.98–1.13; $p = 0.14$). After Bonferroni correction, on- versus off-hours cannulation was not significantly associated with any of the specific complications after adjusting for all the confounders (**Table 3** and **Fig. 2**). We also performed the multivariable analyses excluding covariates with more than 10% missing data (**Supplemental Table 3**, http://links.lww.com/CCX/A994), whereas this increased our case numbers, and it did not change the direction or significance level of the associations.

Our exploratory analysis revealed that there was no significant interaction for our primary outcome of hospital mortality. However, there was a significant interaction for mode of ECLS (VV vs VA ECLS) and the association between on-/off-hour cannulation and any complication ($p = 0.019$; **Supplemental Table 4**, http://links.lww.com/CCX/A994). The adjusted OR being cannulated off-hours and any complications was significantly elevated in the group receiving VV ECLS (adjusted OR, 1.43; 95% CI, 1.04–1.98; $p = 0.028$) but not in the group receiving VA ECLS (adjusted OR, 0.91; 95% CI, 0.78–1.07). None of the other interaction terms were significant.

TABLE 2.
Outcomes

Outcomes	On-Hours (n = 4,331)	Off-Hours (n = 5,069)	p
Hospital mortality, n (%)	1,894 (44.1)	2,220 (44.0)	0.93
Any complication, n (%)	1,921 (44.4)	2,115 (41.7)	**0.01**
Number of complications, median (IQR)	0 (0–3)	0 (0–2)	**0.005**
Specific complications,[a] n (%)			
Complications			
Mechanical	782 (18.1)	870 (17.2)	0.26
Hemorrhagic	909 (21.0)	932 (18.4)	**0.002**
Neurologic	448 (10.3)	583 (11.5)	0.07
Renal	810 (18.7)	885 (17.5)	0.12
Cardiovascular	1,199 (27.7)	1,278 (25.2)	0.007
Pulmonary	373 (8.6)	400 (7.9)	0.21
Metabolic	481 (11.1)	489 (9.7)	0.02
Limb	21 (0.5)	19 (0.4)	0.41
Length of stay in survivors, median (IQR)	45 (26–78)	41 (24–74)	**0.018**
Hours on extracorporeal life support in survivors, median (IQR)	122 (71–215)	130 (78–213)	0.23

IQR = interquartile range.

[a]Bonferroni correction for specific complications, $p < 0.006$

Boldface values indicate values <0.05 for mortality, any complication, LOS, and hours on ECLS. Value <0.006 for specific complications (Bonferroni correction).

TABLE 3.
Results of Multivariable Model for Different Outcomes for Off-Hours vs On-Hour Cannulation (Complete Case Analysis, $n = 6144$)

Outcomes	Model	Point Estimate (95% CI)	*p*
Hospital mortality	Logistic	0.95 (0.85–1.07)	0.41
Any complication	Logistic	1.02 (0.89–1.17)	0.75
Number of complications	Linear	−0.008 (−0.11 to 0.09)	0.87
Specific complications[a]	Model	Point Estimate (99.4% CI)	*p*
Mechanical	Logistic	1.15 (0.92–1.43)	0.09
Hemorrhagic	Logistic	0.94 (0.79–1.13)	0.37
Neurologic	Logistic	1.22 (0.95–1.58)	0.03
Renal	Logistic	0.97 (0.76–1.24)	0.74
Cardiovascular	Logistic	0.94 (0.79–1.11)	0.33
Pulmonary	Logistic	0.92 (0.70–1.23)	0.43
Metabolic	Logistic	0.87 (0.69–1.10)	0.11
Limb	Logistic	0.50 (0.13–1.93)	0.16
Specific complications[a]	Model	Point Estimate (95% CI)	*p*
Hours on extracorporeal life support	Competing risk	1.03 (0.96–1.11)	0.36
Length of stay	Competing risk	1.05 (0.98–1.13)	0.14

[a]Bonferroni correction for specific complications, $p < 0.006$, 99.4% CI.
Adjusted for age, sex, race, extracorporeal life support (ECLS) type (pulmonary, cardiac, and ECPR), time to intubation, time from intubation to ECLS, number of Complex Chronic Conditions, pre-ECLS blood pressure, number of inotropes/vasopressors, pH, and Po_2 and cardiopulmonary bypass run within 24 hr prior to ECLS cannulation.
All models took clustering on center level (random effect) into account.
Point estimate for logistic model is odds ratio, the linear coefficient for linear model, subhazard ratio for discharge for length of stay, and the subhazard ratio for coming off ECLS for hours on ECLS.

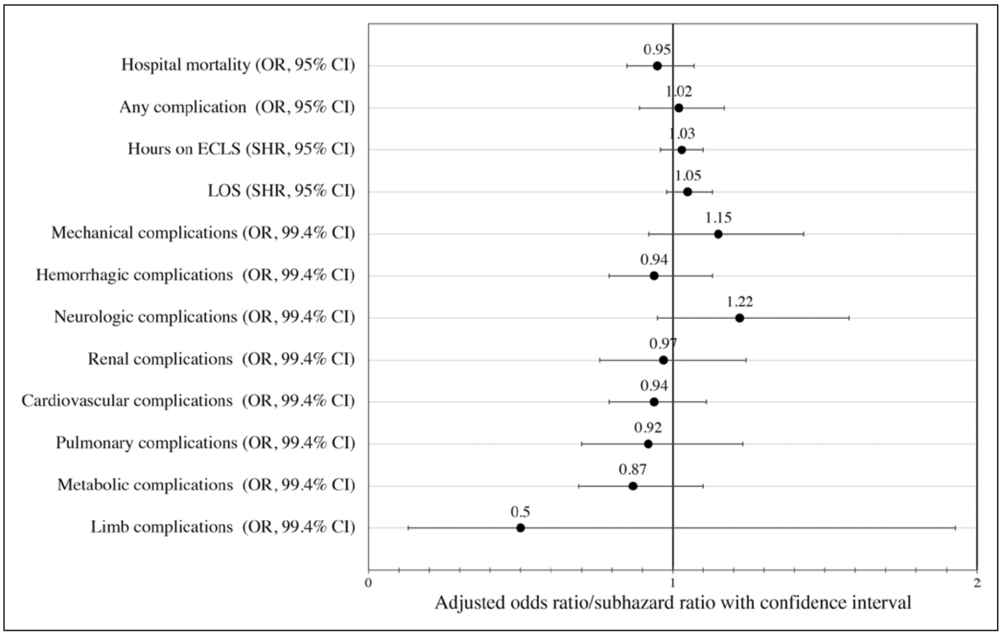

Figure 2. Forest plot for adjusted point estimates and CIs for different outcomes for off-hours vs on-hours cannulation. OR = odds ratio.

DISCUSSION

The main finding of this study was that there were no differences in mortality or complication rates between pediatric patients placed on ECLS during weekday daytime hours compared with weekday nighttime, weekend, or holiday hours. We found no differences based on the type (pulmonary, cardiac, or eCPR) of support. Our exploratory analysis revealed a significant interaction between complications and off-hours initiation in patients receiving VV, but not VA, ECLS. To our knowledge, this is the first study to examine this question in a large multicenter cohort of exclusively pediatric (>30 d and < 18 yr old) patients. This finding suggests that, in aggregate, the current pediatric ECLS infrastructure in the United States provides adequate capabilities for the initiation of ECLS across all hours of the day.

Gonzalez et al (13) compared outcomes primarily in a neonatal population (n = 176; 89% neonate) after initiation of ECLS during on-hours compared with off-hours. Similar to our findings in pediatric patients, they did not observe any differences in mortality or complication rates between the groups. Achuff et al (12) described a 10-year experience from a single center (n = 253), examining outcomes for neonatal and pediatric patients placed on ECLS in a cardiac ICU. In a subgroup of patients (those who had not undergone surgery prior to ECLS), they found increased mortality associated with initiation at night or on weekends. Over half of the patients in that study underwent eCPR (12). Burke et al (11) reported outcomes for 53 pediatric patients who underwent eCPR in a single center. They found that it took longer to achieve full ECLS support and that there was greater neurologic injury for patients undergoing eCPR at night and on weekends compared with weekdays. Similarly, Lee et al (10) found worse outcomes, specifically higher mortality and more complications, in adult patients undergoing eCPR on weekends compared with weekdays. Together, these smaller studies of mixed populations suggest that eCPR outcomes may be particularly impacted by the timing of ECLS initiation. When controlling for the type of ECLS, including eCPR, we did not find similar associations in pediatric patients. Differences between our findings and those of these prior studies may relate to our exclusion of neonatal and adult populations and the much larger cohort. Potential interactions between time of day, cardiac arrest, and ECLS and their impact on outcomes remain an active area of study, with conflicting data in the available literature (17–20).

Our exploratory analysis revealed a significant interaction between increased complications and off-hours initiation in the VV, but not VA, ECLS group. The potential reasons for this association and clinical significance are unclear, but intriguing. It is often not clear whether patients would be better served by VV or VA ECLS, and the difference in complications between these groups during off-hours could represent differences in decision-making. VV cannulation might be done more often by nonsurgeons during off-hours compared with on-hours, even though limited evidence suggests that this can be done safely (21). On the other hand, specially trained critical care or interventional radiology providers might be more available on-hours, with cannulation falling to surgeons more often during off-hours. Further study is needed to validate differences in complications in pediatric patients cannulated onto VV ECLS during off-hours. In addition, limitations of the data available in the registry for the study period precluded an analysis of time from cannulation to the development of a complication. It is possible that such an analysis could identify differences, such as early compared with late complications, between on- versus off-hours initiations. The data collection in the ELSO registry as it pertains to complications is relatively limited: for example, details around complications and severity of each complications are often not captured. We could have missed differences in severity of certain complications between the two groups.

In our study, we defined on-hours as 0700 until 1859 weekdays, similar to other pediatric studies (6, 13, 17). We recognize that there must be variation between centers in the exact timing of hand-off from on-hours to off-hours teams. In addition, hand-off times likely vary within centers between the different medical and surgical team members involved in the initiation of ECLS. Furthermore, some groups within centers may rotate out of sync with 12-hour blocks, for example, swing shifts or 8-hour shifts. In choosing the times for our analysis, we assume that the off-hours time period captures the majority of off-hours shifts, despite variability in specific center schedules. Our analysis does not account for potential day and night variations within weekends. We restricted our analysis to U.S. centers and used U.S. holidays in our definition of off-hours, based on an assumption that most institutions deploy staffing similar to weekends and nighttime during these days. However, it is possible that normal daytime weekday staffing for some institutions does not change on national holidays, which might introduce error in our analysis.

Importantly, our analysis did not depend on pre hoc assumptions about the superiority of on- or off-hours for the initiation of ECLS, and outcomes may be similar due to competing advantages and disadvantages. For example, increased staffing during on-hours may be matched to scheduled clinical activities with less availability to respond to unscheduled ECLS cannulation compared with off-hours. Conversely, off-hours cannulation may be hampered by decreased resources, such as off-site team members. As such, the present study cannot determine whether similar outcomes between on- and off-hours ECLS initiations reflect a lack of variation or multiple differences that offset one another. Furthermore, the results do not preclude the possibility that outcomes could be improved within either time frame.

In order to adjust for patient complexity, we used the Pediatric CCC classification system (Version 2), a system that has been used in a number of outcome studies. The update second version includes ICD-10 codes, diagnoses related to the neonatal period, and domain codes that capture medical technology dependence and organ transplant, including bone marrow transplant (14). Fewer diagnosis-based scoring systems have been validated in the pediatric population compared with the adult population, where several systems are well established such as the Elixhauser Comorbidity Index and Charlson Comorbidity Score (22, 23). Scoring systems based on diagnosis codes have inherent limitations compared with severity of illness scores based on physiologic data, such as the Pediatric Index of Mortality score and the Pediatric Risk of Mortality Score that cannot be calculated based on the registry data used in this study (24–26). Nonetheless, more patients in the off-hours group had no CCCs compared with the on-hours group, but outcomes were not different when adjusting for these differences.

Significant strengths of the present study include the multicenter cohort and the large sample size. This study has several important limitations. With the exception of eCPR, the exact timing of ECLS cannulation is at the discretion of the care team, and thus, potential structural differences between on- and off-hours could be intentionally mitigated, or higher risk patients selectively cannulated during regular on-hours. Although these differences were not apparent in the baseline characteristics, the data available in the registry may not capture important clinical differences. The analysis cannot account for potential changes in utilization of ECLS, care advancements, or staffing changes across centers over the 10-year study period. The study period precedes the COVID-19 pandemic and the associated staffing challenges, and thus, the conclusions require confirmation in the current era. Furthermore, the analysis cannot identify which components of the ECLS infrastructure are responsible for maintaining the consistency of care across the hours of the day. Finally, we were not able to incorporate certain important characteristics such as mean airway pressure or lactate into our models due to a high percentage of missing values of these data fields.

After adjusting for patient complexity and other confounders, we found no differences in mortality, complications, or LOS between pediatric patients cannulated for ECLS during regular on-hours compared with off-hours. This is the largest study to date to investigate these associations in a pediatric population.

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The authors have disclosed that they do not have any potential conflicts of interest.

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