Pediatric Resuscitation Practices During the Coronavirus Disease 2019 Pandemic

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Objectives: While most pediatric coronavirus disease 2019 cases are not life threatening, some children have severe disease requiring emergent resuscitative interventions. Resuscitation events present risks to healthcare provider safety and the potential for compromised patient care. Current resuscitation practices and policies for children with suspected/confirmed coronavirus disease 2019 are unknown.

Design: Multi-institutional survey regarding inpatient resuscitation practices during the coronavirus disease 2019 pandemic.

Setting: Internet-based survey.

Subjects: U.S. PICU representatives (one per institution) involved in resuscitation system planning and oversight.

Interventions: None.

Measurements and Main Results: Of 130 institutions surveyed, 78 (60%) responded. Forty-eight centers (62%) had admitted coronavirus disease 2019 patients; 26 (33%) reported code team activation for patients with suspected/confirmed coronavirus disease 2019. Sixty-seven respondents (86%) implemented changes to inpatient emergency response systems. The most common changes were as follows: limited number of personnel entering patient rooms (75; 96%), limited resident involvement (71; 91%), and new or refined team roles (74; 95%). New or adapted technology is being used for coronavirus disease 2019 resuscitations in 58 centers (74%). Most institutions (57; 73%) are using enhanced personal protective equipment for all coronavirus disease 2019 resuscitation events; 18 (23%) have personal protective equipment policies dependent on the performance of aerosol generating procedures. Due to coronavirus disease 2019, most respondents are intubating earlier during cardiopulmonary resuscitation (56; 72%), utilizing video laryngoscopy (67; 86%), pausing chest compressions during laryngoscopy (56; 72%), and leaving patients connected to the ventilator during cardiopulmonary resuscitation (56; 72%). Responses were varied regarding airway personnel, prone cardiopulmonary resuscitation, ventilation strategy during cardiopulmonary resuscitation without an airway in place, and extracorporeal cardiopulmonary resuscitation. Most institutions (46; 59%) do not have policies regarding limitations of resuscitation efforts in coronavirus disease 2019 patients.

Conclusions: Most U.S. pediatric institutions rapidly adapted their resuscitation systems and practices in response to the coronavirus disease 2019 pandemic. Changes were commonly related to team members and roles, personal protective equipment, and airway and breathing management, reflecting attempts to balance quality resuscitation with healthcare provider safety. (*Pediatr Crit Care Med* 2020; XX:00–00)

Key Words: cardiac arrest; cardiopulmonary resuscitation; coronavirus; coronavirus disease 2019; COVID-19; pandemic; resuscitation

Coronavirus disease 2019 (COVID-19), caused by the novel severe acute respiratory syndrome coronavirus 2, was declared a global pandemic by the World Health Organization on March 11, 2020. As of May 20, 2020, COVID-19 has been diagnosed in 216 countries and territories (1) with more than 4.9 million confirmed COVID-19 cases worldwide and over 1.5 million cases and 92,000 deaths in the United States alone (2). Relative to older adults, children account for a low proportion of COVID-19 cases and typically have a milder disease course (3–6). However, a small proportion of children with acute COVID-19 develop severe illness requiring hospitalization or ICU care (6–15). Furthermore, with the emergence of COVID-19-related multisystem inflammatory

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syndrome in children (16), the true burden of severe pediatric illness due to COVID-19 continues to evolve.

The scope and severity of COVID-19 has required hospital systems to rapidly adapt to both effectively care for COVID-19 patients and minimize the risk of transmission to healthcare providers. In-hospital cardiac arrests and other types of acute clinical deterioration represent particularly high-risk scenarios in which personnel safety and patient care may be compromised. To address this, the American Heart Association (AHA) released interim guidance for basic and advanced life support for adults and children with suspected or confirmed COVID-19 on April 9, 2020 (17, 18). However, the extent and nature of actual changes made to in-hospital pediatric resuscitation systems in response to the COVID-19 pandemic are unknown. Awareness of such resuscitation strategies and approaches among institutions may help to reduce system vulnerabilities and to provide the best possible care at the bedside. The objective of this study was to report current practices in the delivery of in-hospital resuscitation care to children during the COVID-19 pandemic. To achieve this, we conducted a survey of hospitals providing critical care services to children in the United States.

MATERIALS AND METHODS

The Institutional Review Board at the Children's Hospital of Philadelphia deemed that this study did not constitute human subjects research. The survey itself and study data were collected and managed using Research Electronic Data Capture (REDCap; Vanderbilt University, Nashville, TN) tools hosted at the Children's Hospital of Philadelphia. REDCap is a secure, web-based software platform designed to support data capture for research studies, providing: 1) an intuitive interface for validated data capture; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for data integration and interoperability with external sources (19). The survey consisted of 28 mandatory questions and additional questions based on conditional branching logic. Survey questions, which were created, edited, and then pilot tested among the entire authorship group, focused on potential adaptations that may be necessary to maintain high-quality resuscitation for patients as well as limit exposure to aerosol generating procedures and ensure protections for healthcare workers. Survey questions were divided according to categories: 1) institutional/respondent demographics; 2) general COVID-19 pandemic response; 3) personnel/team dynamics; 4) personal protective equipment (PPE); 5) technology; 6) cardiopulmonary resuscitation (CPR); 7) emergency airway and ventilation management; 8) extracorporeal support; and 9) limitations of life-sustaining interventions.

PICU representatives with knowledge of hospital resuscitation systems (e.g., PICU medical director, resuscitation committee leader/member) at 130 U.S. hospitals were identified through email, phone calls, and social media and provided with individualized survey links via email. One individual was contacted per institution. In addition to the link, the email provided the purpose of the survey, the contact information for the study leads, and a statement explaining the voluntary and anonymous nature of the survey. The introduction to the survey referenced the AHA's interim guidance on resuscitation in COVID-19 patients, which had been released 2 days prior to the survey's distribution (17). All emails were delivered and the survey remained open for 1 week (April 11, 2020, to April 17, 2020), during which time two reminder emails were sent to individuals who had not yet responded.

All survey responses remained de-identified throughout the survey distribution period and during all analyses. Responses were downloaded from REDCap in spreadsheet form and visualized in Excel (Microsoft Corporation, Redmond, WA). Descriptive statistics were calculated and reported as frequencies and percentages.

RESULTS

Among the 130 individuals surveyed, 78 (60%) responded, each representing a unique institution. Among the 78 responses, all survey questions were completed. **Table 1** summarizes institutional and respondent demographics. Institutions represented 35 states and Washington, DC. Most hospitals (45; 58%) were dedicated children's hospitals within combined adult/pediatric medical centers; 31 (40%) were freestanding children's hospitals; and two (3%) had pediatric beds within combined hospitals. Among respondents, 71 (91%) were either the PICU medical director, division chief, or resuscitation committee member or leader. At the time of the survey, 48 (62%) institutions had admitted at least one patient with COVID-19 to either ICU or non-ICU locations; 26 (33%) reported code team activation for at least one suspected or confirmed COVID-19 patient; and 20 (26%) reported having performed CPR on at least one patient with suspected or confirmed COVID-19.

Table 2 summarizes general COVID-19 resuscitation elements, including details of personnel, PPE, and the use of technology. Seventy-one centers (91%) reported implementing changes to their inpatient emergency response systems in response to COVID-19 with the majority (59; 76%) implementing new protocols for patients with suspected or confirmed COVID-19 and many (27; 38%) implementing changes to existing protocols for all patients. A minority of centers (17; 22%) decreased the number of individuals receiving code team notifications, while almost all (75; 96%) decreased the number of individuals entering patient rooms during at least some resuscitation events. Seventy-four (95%) added or refined specific roles (e.g., PPE monitor). Most institutions (71; 91%) limited or prohibited resident physician involvement in the COVID-19 resuscitation events, while smaller proportions limited fellow (23; 29%) or advanced practice provider (38; 49%) involvement. Most (60; 77%) have some type of regularly occurring training or organizing activity related to COVID-19 resuscitation events. During COVID-19 resuscitation events, 58 institutions (74%) are using new or adapted technologies, most commonly video laryngoscopes and hands-free audio communication devices. Only three institutions (4%) endorsed plans

TABLE 1. Demographics and Coronavirus Disease 2019 Experience

Question/Topic	*n* (%)
Hospital type	
Freestanding children's hospital	31 (39.7)
Dedicated children's hospital within combined adult/pediatric center	45 (57.7)
Pediatric beds within combined adult/pediatric center	2 (2.6)
Total pediatric hospital beds	
< 100	10 (12.8)
100–199	30 (38.5)
200–299	16 (20.5)
300–399	15 (19.2)
> 399	7 (9.0)
PICU type	
Combined PICU/CICU	32 (41.0)
PICU with no CICU at institution	14 (17.9)
PICU with separate CICU at institution	32 (41.0)
PICU (or PICU/CICU if combined) beds	
< 16	14 (17.9)
16–30	44 (56.4)
31–45	11 (14.1)
> 45	9 (11.5)
Region[a]	
Northeast	17 (21.8)
South	21 (26.9)
Midwest	20 (25.6)
West	20 (25.6)
Respondent role[b]	
PICU medical director or division chief	22 (28.2)
Resuscitation committee member or leader	49 (62.8)
Attending intensivist (and neither of above)	5 (6.4)
Other	2 (3.8)
Admitted children with confirmed COVID-19 to date	
Yes (to the PICU only)	5 (6.4)
Yes (to non-PICU locations only)	15 (19.2)
Yes (to both PICU and non-PICU locations)	28 (35.9)
No	30 (38.5)
Code team activation for confirmed/suspected COVID-19 patients to date	
Yes (for known or later confirmed COVID-19 patient)	6 (7.7)
Yes (for suspected COVID-19 patient who was later negative or not confirmed)	20 (25.6)
No	51 (65.4)
Unsure	1 (1.3)
Cardiopulmonary resuscitation performed on confirmed/suspected COVID-19 children to date	
Yes (for known or later confirmed COVID-19 patient)	3 (3.8)
Yes (for suspected COVID-19 patient who was later negative or not confirmed)	17 (21.8)
No	58 (74.4)
Unsure	0 (0)

CICU = cardiac ICU, COVID-19 = coronavirus disease 2019.

[a]Determined by investigators based on U.S. Census Bureau region definitions.

[b]One respondent responding "Other" and reporting to be both PICU medical director and resuscitation committee chairperson was classified as PICU medical director. Survey responses from 78 U.S. pediatric hospital representatives.

TABLE 2. General Coronavirus Disease 2019 Resuscitation System Response

Question/Topic	*n* (%)
COVID-19-related changes to inpatient emergency response systems	
Yes (for ICU and non-ICU patients)	67 (85.9)
Yes (for ICU patients only)	4 (5.1)
Yes (for non-ICU patients only)	0 (0)
No (but plan to implement changes)	0 (0)
No (with no plans for change)	7 (9.0)
Type of change implemented[a]	
Changes to existing protocols for all patients	27 (38.0)
New protocol specifically for confirmed COVID-19 patients	10 (14.1)
New protocol specifically for suspected or confirmed COVID-19 patients	49 (69.0)
Other	1 (1.4)
Decreased number of personnel receiving code team notifications	
Yes (for all events)	8 (10.3)
Yes (for confirmed COVID-19 patients)	1 (1.3)
Yes (for suspected or confirmed COVID-19 patients)	8 (10.3)
No	61 (78.2)
Decreased number of responders entering patient room during resuscitation	
Yes (for all events)	22 (28.2)
Yes (for confirmed COVID-19 patients)	3 (3.8)
Yes (for suspected or confirmed COVID-19 patients)	50 (64.1)
No	2 (2.6)
Variable/at discretion of team	1 (1.3)
Limited roles of physician trainees and APPs during COVID-19 resuscitations[a]	
Residents prohibited from direct patient care	32 (41.0)
Fellows prohibited from direct patient care	3 (3.8)
APPs prohibited from direct patient care	12 (15.4)
Limiting but not prohibiting resident involvement in direct patient care	39 (50.0)
Limiting but not prohibiting fellow involvement in direct patient care	20 (25.6)
Limiting but not prohibiting APP involvement in direct patient care	26 (33.3)
No change in policy	7 (9.0)
Addition or refinement of specific roles[a]	
PPE monitor/observer	67 (85.9)
Dedicated communicator outside room to relay information	63 (80.8)
Anesthesia or other dedicated airway personnel	41 (52.6)
Predetermined chest compressors	25 (32.1)
"Runner"	26 (33.3)
Designated crowd control personnel	32 (41.0)
Other	1 (1.3)
None	4 (5.1)

(*Continued*)

TABLE 2. (*Continued*). General Coronavirus Disease 2019 Resuscitation System Response

Question/Topic	*n* (%)
Training/organizing activities[a]	
Meetings or huddles of code team each day or each shift	23 (29.5)
Simulation in standard educational environment	15 (19.2)
In situ simulation in ICU or other inpatient units	45 (57.7)
Other	6 (7.7)
None	18 (23.1)
New or adapted technology during COVID-19 resuscitation[a]	
Tablet or other videoconference-capable device	17 (21.8)
Hands-free audio communication device	24 (30.8)
Video laryngoscope	49 (62.8)
Digital stethoscope	3 (3.8)
Dedicated portable or ultra-portable ultrasound	6 (7.7)
Mechanical cardiopulmonary resuscitation device	3 (3.8)
Other	2 (3.8)
None	20 (25.6)
PPE practice during resuscitation of suspected or confirmed COVID-19 patients	
Standard droplet/contact precautions (gown, eye shield, facemask) in all cases	3 (3.8)
Enhanced precautions (N95 or powered air-purifying respirator or equivalent) in all cases	57 (73.1)
Dependent on whether aerosol generating procedures are being performed	17 (21.8)
Other	1 (1.3)
PPE practice during resuscitation of in patients not suspected of COVID-19	
All patients treated as potential COVID-19 patients	25 (32.1)
Increased PPE standards compared to previous, but not to same level as COVID-19	22 (28.2)
No change to previous standards	24 (30.8)
Other	7 (9.0)

APP = advanced practice provider, COVID-19 = coronavirus disease 2019, PPE = personal protective equipment.
[a]Multiple responses allowed.
Survey responses from 78 U.S. pediatric hospital representatives.

to use mechanical CPR devices. Regarding PPE, most institutions (57; 73%) are utilizing enhanced precautions (e.g., N95 mask or powered air-purifying respirator) for all patients with suspected or confirmed COVID-19, while 18 (23%) have policies based on whether or not aerosol generating procedures are being conducted and three (4%) are not utilizing enhanced PPE precautions. For non-COVID-19 patients, 47 institutions (60%) made changes to PPE policy.

Table 3 contains responses pertaining to clinical practices during resuscitation events. Most institutions (55; 71%) are not altering the frequency of chest compressor switches during CPR. During CPR without an advanced airway in place, nearly half of respondents (38; 49%) reported a preference for hands-only CPR or limitation of bag-mask ventilation, while 35 (45%) plan to provide standard CPR with chest compressions and ventilations. The majority plan to intubate earlier in the course of CPR to limit aerosol generation from bag-mask ventilation, will use video laryngoscopy as the primary method for intubation, and will pause chest compressions during laryngoscopy. For intubated patients, most respondents (56; 72%) plan to provide ventilations through the ventilator as opposed to hand ventilation. If in the prone position, plans for the delivery of prone CPR versus transition to the supine position are variable.

The use of extracorporeal membrane oxygenation (ECMO) support and details regarding limitations of interventions in COVID-19 patients are in **Supplemental Table 1** (Supplemental Digital Content 1, http://links.lww.com/PCC/B428). Among 66 institutions that identified themselves as ECMO centers, 56 (85%) said they are offering ECMO to COVID-19 patients. Among the 47 centers that perform extracorporeal CPR (ECPR) for in-hospital cardiac arrest, policies regarding the provision of ECPR to suspected or confirmed

TABLE 3. Cardiopulmonary Resuscitation and Emergency Airway and Ventilation Management in Children With Suspected or Confirmed Coronavirus Disease 2019

Question/Topic	*n* (%)
Frequency of compressor switches	
No different than usual practice	55 (70.5)
More often than usual to avoid provider fatigue and limit individual exposure	3 (3.8)
Less often than usual to limit the number of providers in the room	12 (15.4)
Unsure/variable	8 (10.3)
Ventilation strategy during CPR in patient without advanced airway in place	
Hands-only CPR in all cases to limit aerosol generation	1 (1.3)
Preference for hands-only CPR or limitation of BMV depending on arrest etiology and other factors	37 (47.4)
Standard CPR with chest compressions and ventilations	35 (44.9)
Unsure/variable	2 (2.6)
Other	3 (3.8)
Timing of intubation during CPR	
No different than usual practice	13 (16.7)
Earlier in the course of CPR to limit aerosol generation from BMV	56 (71.8)
Later in the course of CPR to limit aerosol generation from intubation	2 (2.6)
Unsure/variable	7 (9.0)
Primary provider for emergent intubation	
Anesthesiologist who responds as a part of the code team	9 (11.5)
Anesthesiologist or other dedicated airway provider who is called if intubating	10 (12.8)
Attending intensivist unless anesthesiologist present or difficult airway suspected	39 (50.0)
Attending intensivist or critical care medicine fellow unless difficult airway suspected	12 (15.4)
Any appropriately trained team member	3 (3.8)
Other	5 (6.4)
Use of video laryngoscopy as primary emergent intubation method	
Yes (every time and is readily available)	45 (57.7)
Yes (preferred method when readily available)	22 (28.2)
When deemed clinically appropriate, but not as a standard	8 (10.3)
No	2 (2.6)
Unsure/variable	1 (1.3)
Interruption of chest compressions during laryngoscopy	
Yes	56 (71.8)
Not unless having difficulty intubating during chest compressions	11 (14.1)
No, will not interrupt chest compressions for intubation	1 (1.3)
Unsure/variable	10 (12.8)
Ventilation method during CPR in intubated patient	
Through hand ventilation per usual practice	18 (23.1)
Always through the ventilator to limit circuit disconnections	12 (15.4)
Through the ventilator if able to confirm adequate ventilation delivery	44 (56.4)
Unsure/variable	4 (5.1)

(*Continued*)

TABLE 3. (*Continued*). Cardiopulmonary Resuscitation and Emergency Airway and Ventilation Management in Children With Suspected or Confirmed Coronavirus Disease 2019

Question/Topic	*n* (%)
CPR method for intubated patient in the prone position	
Transition to supine position and provide conventional CPR	36 (46.2)
Provide prone CPR through duration of resuscitation	0 (0)
Start prone CPR and consider transition to supine depending on size/age/safety	16 (20.5)
Unsure/variable	22 (28.2)

BMV = bag-mask ventilation, CPR = cardiopulmonary resuscitation.
Survey responses from 78 U.S. pediatric hospital representatives.

COVID-19 patients are variable. The majority of institutions (46/78; 59%) do not have specific protocols regarding limitations of resuscitation-related interventions for suspected or confirmed COVID-19; 25 respondents (32%) reported guidance to not perform prolonged CPR after addressing reversible causes of cardiac arrest while none reported universal "do not resuscitate" orders.

DISCUSSION

The COVID-19 pandemic has driven widespread, rapid, and dramatic changes in the delivery of healthcare. The results of this survey demonstrate that these effects extend to pediatric in-hospital emergency response systems, with over 90% of institutions having implemented resuscitation system changes. Many of the changes implemented are largely congruent with interim AHA guidance (17, 18), while others differ from recommendations and vary among respondents. The extent and nature of changes reflect the tenuous balance and potential conflict between ensuring the delivery of high-quality resuscitation care with that of appropriately protecting healthcare providers. Additionally, despite the relative rarity of severe pediatric COVID-19 reported in the early stages of the pandemic (8, 10, 12, 13), the majority of institutions responding to our survey have cared for pediatric inpatients with COVID-19 and one-third have had code team activations for patients with known or suspected COVID-19.

The majority of institutions surveyed have made significant changes to their resuscitation team's composition or to individual roles during COVID-19-related resuscitations and almost 40% have introduced such changes for all resuscitation events. Nearly all report a lower number of personnel entering the rooms of COVID-19 patients during resuscitation events and, strikingly, limitation or prohibition of trainee and advanced practice provider involvement was commonly reported. Reducing the number of individuals potentially exposed to COVID-19 during these events is important and responsible, especially as it applies to trainees. Of course, as the pandemic persists, the balance between reducing unnecessary exposures and providing education and training to all members of the healthcare team must be continually reassessed. With fewer providers at the bedside and potential limitations such as PPE constraints and communication difficulties, we anticipated that teams would adapt through the utilization of technology and the implementation of less traditional team roles. Indeed, the majority of respondents report using either communication devices or clinical tools specifically acquired or adapted for this purpose. Additionally, 95% have added or refined at least one specific role; most have a PPE monitor or observer to ensure personnel are appropriately protected and a designated individual to relay communication between team members inside and outside of the patient room. The degree of variability in how teams are being restructured is both expected and necessary as each center must consider its existing systems, assets, and vulnerabilities.

Given the variability in PPE availability across the country, we hypothesized that PPE policies would differ among hospitals. Indeed, responses varied in terms of the clinical scenarios in which "enhanced" PPE is used for patients with COVID-19. Importantly, the "right answer" regarding when enhanced PPE is advisable is not known. Although bag-mask ventilation and tracheal intubation are aerosol generating procedures, there is a lack of high-quality data regarding aerosol generation and infection risk from chest compressions alone (20, 21), leading to conflicting recommendations from national and international organizations (17, 22–24). Cardiac arrest care is complex, and it is inherently difficult to predict what procedures may be required over the course of a resuscitation. Although donning enhanced PPE can result in initial delays beginning CPR (25), real-time PPE-related decision-making and delays associated with changing PPE during CPR may similarly have adverse effects on CPR quality and other components of resuscitation. Additionally, many centers have applied their expanded PPE policies to all resuscitations regardless of COVID-19 status. Although not specifically queried, we postulate that these policies vary based on PPE availability as well as local COVID-19 prevalence and testing practices that contribute to the likelihood of unanticipated exposures.

Recently published guidelines for resuscitation in confirmed and suspected COVID-19 patients recommend that rescuers "prioritize oxygenation and ventilation strategies with lower aerosolization risk (17, 18)." Consistent with these recommendations, most of our respondents reported that they would intubate earlier in the course of CPR to limit ongoing aerosol generation with bag-mask ventilation, would use video

laryngoscopy, would pause chest compressions during laryngoscopy to reduce risk to airway personnel, and would keep the patient connected to the ventilator during CPR. Notably, given the lack of rigorous prospective studies for airway and ventilation management during pediatric cardiac arrest, the potential impact of such modifications on resuscitation outcomes is unknown. Conversely, strong observational evidence supports the recommendation that children without an advanced airway in place at the time of cardiac arrest require assisted ventilation in addition to chest compressions (26, 27). Hands-only CPR is appropriate in some adult cardiac arrest populations, but the majority of children with in-hospital cardiac arrest have progressive respiratory failure as an arrest etiology (28, 29) and this strategy is therefore not endorsed in children with suspected or confirmed COVID-19 (17, 18). Thus, it is somewhat surprising that nearly half of respondents endorsed a preference for hands-only CPR or limitation of bag-mask ventilation depending on arrest etiology and other factors. The optimal approach is likely one in which resuscitation teams aim to provide standard CPR with compressions and ventilations while focusing on donning appropriate PPE, ensuring an adequate seal while manually ventilating, and moving toward early intubation to limit aerosolization and potential risk to providers as detailed in the AHA's guidance (17, 18).

Differences in the approaches to adult and pediatric resuscitation were highlighted by how our respondents indicated they would provide CPR to intubated patients who are in the prone position at the time of cardiac arrest. The majority would either immediately transition to the supine position (46%) or were unsure or variable in their approach (28%), while 16 respondents (21%) would start prone CPR and then consider transition to a supine position. No respondents would uniformly provide prone CPR for the duration of the resuscitation. Interim guidance for adults with suspected or confirmed COVID-19 endorses the provision of CPR in the prone position to avoid ventilator disconnection and/or inadvertent extubation, while pediatric guidance allows for a size-based approach as infants and smaller children can likely be more easily and safely transitioned to a supine position (17, 18). Data regarding the efficacy of prone CPR is limited and a preference to transition children to the supine position is reasonable. However, pediatric resuscitation teams should be aware of prone CPR as a potentially safe option, especially for larger patients (30, 31). Similarly, mechanical CPR devices are a reasonable means of reducing provider exposure during adult resuscitation, but use in children is limited by height and weight restrictions of commercially available devices (17, 18, 32). Therefore, only three of our respondents indicated plans to potentially use mechanical CPR devices in the resuscitation of patients with suspected or confirmed COVID-19.

The extraordinary circumstances of the COVID-19 pandemic have triggered discussion regarding the rationing of resources and the limitation of potentially futile therapies for particular populations of patients (33). Coupled with the high-intensity nature of resuscitation care and risks to rescuers, the appropriateness of performing CPR on patients with COVID-19 has been debated (34–36). None of the institutions surveyed in this study were prohibiting CPR or instituting specific time limits on resuscitation duration as has been advocated by some groups (36). In fact, the majority (59%) do not have a specific policy, although 32% reported guidance to avoid prolonged CPR after reasonably addressing reversible causes of cardiac arrest. Indeed, while more prescriptive guidance may be necessary in adult institutions with a high prevalence of COVID-19, the relative rarity and heterogeneity of severe pediatric COVID-19 (10–13) justifies a more nuanced and personalized approach. As with other critically ill children, cardiac arrest secondary to progressive organ failure refractory to available therapies should prompt discussions regarding the futility of CPR or other therapies. However, children with COVID-19 can certainly suffer cardiac arrest due to acute reversible etiologies for which CPR can be an appropriate lifesaving intervention. The AHA endorses such a strategy, urging proactive discussions regarding goals of care and consideration of "COVID-19 status, comorbidities, and severity of illness to estimate the likelihood of survival (18)." This guidance also recognizes a lack of evidence supporting ECPR for children with COVID-19 (17, 18). Responses regarding ECPR for in- or out-of-hospital cardiac arrest among the ECMO centers included in this survey were mixed, with substantial proportions not having specific guidance on the topic but several others deciding not to perform ECPR on patients with COVID-19. These decisions likely reflect institutional considerations regarding the safety and efficacy of this therapy in light of the extensive resources and additional personnel required as well as the paucity of data supporting pediatric ECPR in noncardiac populations (37).

This study has limitations. First, a 60% response rate is reasonable but not ideal and the centers participating in this study may not fully reflect the diversity of pediatric resuscitation care provided in the United States. Second, survey responses are inherently prone to bias; even in the setting of anonymity, respondents may have been more likely to endorse responses that were perceived as more appropriate or were more consistent with guideline recommendations. We referred to the AHA interim guidance for resuscitation in COVID-19 patients upon distributing the survey to ensure all participants were equally aware that these guidelines were in existence. However, since the AHA statement was published online just 2 days prior to the survey's distribution, it is likely that institutional policies were largely enacted independent of these guidelines. Third, survey responses reflect policy and intent, but they may not accurately represent actual practice or performance. Further investigations should address differences in resuscitation quality and outcomes during the COVID-19 pandemic era. Fourth, only six institutions had code team activations on confirmed COVID-19 patients at the time of this survey. It is likely that as individual hospitals gain practical experience and the COVID-19 pandemic continues to evolve, resuscitation plans and practices will change.

CONCLUSIONS

Pediatric in-hospital resuscitation systems have rapidly adapted to the COVID-19 pandemic. Institutions have created or changed policies regarding resuscitation team members, individual roles,

PPE, and airway and breathing management. In many domains, the actual changes implemented vary, signifying both the relative absence of data to support particular practices and the need for individualization of responses based on local factors. Widespread change in resuscitation policy, procedure, and practice across 78 pediatric institutions reflect efforts to balance hospital and societal commitments to providing high-quality, evidence-based care with that of healthcare provider safety.

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