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Efficacy and Safety of Pediatric Critical Care Physician Telemedicine Involvement in Rapid Response Team and Code Response in a Satellite Facility

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Abstract

Objective: Satellite inpatient facilities of larger children's hospitals often do not have on-site intensivist support. In-house rapid response teams (RRT) and code teams may be difficult to operationalize in such facilities. We developed a system using telemedicine to provide pediatric intensivist involvement in RRT and code teams at the satellite facility of our children's hospital. Herein, we compare this model to our in-person model at our main campus.

Design: Cross-sectional

Setting: A tertiary pediatric center and its satellite facility

Patients: Patients admitted to the satellite facility

Interventions: Implementation of a RRT and code team model at a satellite facility utilizing telemedicine to provide intensivist support.

Measurements: We evaluated the success of the telemedicine model through three a priori outcomes: 1) reliability: involvement of intensivist on telemedicine RRTs and codes; 2) efficiency: time from RRT and code call until intensivist response; and 3) outcomes: disposition of telemedicine RRT or code calls. We compared each metric from our telemedicine model to our established main campus model.

Main Results: Critical care was involved in satellite campus RRT activations reliably (94.6% of the time). The process was efficient (median response time 7 minutes, mean 8.44 minutes) and

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Article Tweet:
Telemedicine #PedsICU support for rapid response and code teams can provide comparable outcomes to an in-person model for remote facilities

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effective (54.5 % patients transferred to pediatric intensive care unit, similar to the 45–55% monthly rate at main campus). For code activations, the critical care telemedicine response rate was 100% (6/6), with a fast response time (median 1.5 minutes). We found no additional risk to patients, with no patients transferred from the satellite campus requiring a rapid escalation of care defined as initiation of vasoactive support, >60 ml/kg in fluid resuscitation, or endotracheal intubation.

Conclusions: Telemedicine can provide reliable, timely, and effective critical care involvement in RRT and Code Teams at satellite facilities.

Keywords

Telemedicine; Hospital Rapid Response Team; Code Team

Introduction

In person code teams and rapid response teams (RRTs) bring critical care expertise including diagnostic and procedural skills to the bedside of deteriorating patients outside of the intensive care unit (ICU). In pediatrics, the use of RRTs is associated with significant reductions in mortality and codes outside the ICU (1–4). The initiation of RRTs is supported by the Joint Commission and the Institute for Healthcare Improvement, and most children's hospitals now have RRTs (5, 6). It is less clear, however, how to bring the requisite expertise to the bedside of children cared for in smaller community hospitals, the satellite facilities of free-standing children's hospitals, or other hospitals without an on-site Pediatric ICU (PICU).

Cincinnati Children's Hospital opened a satellite facility in 2008 in order to provide care for patients from a growing population north of the city of Cincinnati. Previous to the opening of the satellite facility, patients from this area received all care at the Cincinnati Children's Hospital main campus. The satellite facility is located approximately 23 miles north of the 500 bed main campus, which has a 36 bed PICU and well established RRT and Code Teams led by a pediatric critical care fellow. The initial design for the satellite facility included 12 inpatient beds, along with a full-service Emergency Department, 8 operating rooms, a large number of specialty clinics, and other support services such as radiology, physical, occupational, and speech therapy. The inpatient beds were staffed twenty four hours a day by an onsite hospitalist. There was no on-site pediatric intensive care unit or pediatric critical care physician. Pediatric critical care physicians were available for phone consultation as needed. In this initial model, if the onsite hospitalist had a concern about a deteriorating patient, she or he paged the on call intensivist at the main campus and arranged for transfer to the PICU. There was no RRT or Code Team for the satellite campus, and all inpatients whose clinical status was concerning to the covering hospitalist were transferred to the PICU at the main campus. Patients requiring immediate higher level care were moved to the satellite Emergency Department for stabilization prior to transfer.

Due to a continuously growing population in the area served by the satellite facility, the satellite inpatient ward was expanded to 42 beds. The inpatient ward continued to be staffed by an onsite hospitalist 24 hours per day. An on-site Pediatric Critical Care Unit was not part of the expansion. In order to provide safe and effective care for a larger volume of patients, with an expected increase in acuity and complexity, a new care model was necessary. Our group has previously described the process of utilizing simulation to develop a care model for the satellite facility (7).

Our objectives here are two-fold: 1) to describe critical learnings from the development and implementation of our telemedicine model, and 2) to compare reliability, efficiency, and effectiveness outcomes between our telemedicine model and the in-person model at our main campus.

Materials and Methods

IRB

Institutional IRB approval was sought, and this study was determined not human subjects research.

Development of the staffing model

A multidisciplinary group of leaders composed of representatives from the hospital medicine faculty, critical care faculty, nursing, respiratory therapy, the Chief of Staff, patient safety leadership, and the simulation center was tasked with developing the new care model for the expanded inpatient unit during the planning stages of this expansion, prior to construction beginning. It was decided that critical care support by telemedicine was necessary, as well as the development of a RRT and Code Team at the satellite campus, and that all inpatient rooms at the satellite facility would include dedicated telemedicine capabilities (Table 1). The group's goal was to develop systems that ensured safe, effective, and timely care that was at least the same, if not higher, quality than the main Campus.

Development of the telemedicine infrastructure

In order to implement a telemedicine program to provide critical support to the satellite facility, telemedicine infrastructure was needed in both the main and satellite facilities. At the satellite campus, each patient room was equipped with an audiovisual system that supported telemedicine (Cisco SX20 Codec). In addition, the satellite facility maintained mobile telemedicine carts as a backup in case of primary system technical issues (Avizia CA750 with a Cisco SX20 Codec). At the main campus, a telemedicine system was installed in the attending office space located in the PICU (Cisco EX90). This system allows someone at one telemedicine portal to dial into another location, but not to remotely view that area unless actively answered by someone at the other location. At both facilities, the system allowed for both audio and visual communication with the provider at the other facility. In addition, the system at the satellite facility had a stethoscope attachment that allowed for remote examination by the intensivist.

Activation of an RRT involved calling a dedicated phone line that was uniform throughout our system. A code was activated primarily by pulling the code switch which activated the code pager system through a dedicated transmitter, or by calling a dedicated phone line that was unique for the location. Both systems used the existing pager systems. The intensivist responsible for responding were notified via the same code pager utilized for base campus codes. The page would indicate if the activation was an RRT or code. These code pagers were held by two on service fellows. In the event that both on service fellows were occupied, the on service attending would respond. Similar to the existing model at the base campus, the intensivist was expected to respond to a RRT within 15 minutes and a code immediately. The 15 minute response time expectation was determined through multidisciplinary discussions when the RRT began at the base campus >10 years ago (1). There were rare occasions where RRT response was greater than 15 minutes, usually due to ICU staff being busy with other critically ill patients. In this setting someone was usually assigned to make contact with the satellite facility, using residents or nurse practitioners to assess and relay information before a more formal RRT could be performed.

The base and satellite facility utilize the same electronic medical record (Epic), so providers at both locations had access to the same clinical data about a patient. On admission to the satellite facility, parents were given the option to sign consent allowing for the use of telemedicine during their child's admission. If they did not sign consent any potential non-urgent need for escalation of care would occur by the old system - a direct phone call from the satellite hospitalist to the main campus critical care physician. In the event of an urgent need for escalation of care or a code, families were notified on admission that telemedicine would be used.

Development of telemedicine processes using simulation

In addition to providing the necessary infrastructure for telemedicine, processes for the use of the technology for RRT and codes were developed. Our group has previously described the development of these processes (7). In brief, the leadership group based the initial team structure and roles on the model from the main campus. Using this model, the group was able to evaluate how the team structure at the satellite campus needed to evolve based on staffing differences between the two campuses. One of the primary questions that arose during this process was: who should lead the team, the on-site hospitalist or the critical care provider via telemedicine? The Simulation Laboratory was used to test and refine the model over a period of 8 months prior to the new unit opening. Initially the critical care provider would physically come to the simulation room and act as if they were remotely located; later the simulation room was fitted with telemedicine and the intensivist would call in from a different location. Additionally, it was decided that there would be two pediatric critical care trained nurses working at all times at the satellite facility to provide care for the expected patients with higher acuity admitted to the satellite after expansion, including patients requiring continuous albuterol and high flow nasal cannula. Historically, these were considered higher risk patients and were automatically admitted to the base campus PICU. Purposefully, only one of the critical care nurses was included on the code team so that the other could function in a supervisory role for the rest of the unit during an ongoing code. Using established methods, learnings from simulations including errors, adverse events, and latent safety threats, were recorded, catalogued, and reviewed by our multidisciplinary team (8–13).

Measure definitions

We employed three measures to evaluate the success of the telemedicine model. Reliability was measured as the proportion of involvement of critical care on all telemedicine RRTs and code calls. Efficiency was defined as the time between telemedicine call and critical care response. We examined two related outcomes: proportion of patients with a disposition to the ICU for each call, as well as proportion of patients transferred to the ICU that required aggressive treatment in the first hour in the ICU. We utilized a metric previously described by our research team called an Emergency Transfer to define aggressive treatment (14). Patients who met emergency transfer criteria had intubation, initiation of a vasoactive agent, or >60 ml/kg in fluid resuscitation within one hour of transfer to the main campus PICU. This metric was designed to identify significant clinical deterioration that was proximal to a cardiorespiratory arrest, as arrests are quite rare in our system.

Analysis

In the case of each outcome measure we first stratified between RRT and code calls. We then compared each metric from our telemedicine model to our long-established in-person main campus model using Chi-squared and Fisher's exact test as appropriate.

Results

Learnings from Simulation

Several consensus learnings from the simulation debriefs were utilized to change the rapid response model (7). These learnings led to the inclusion of several differences between the telemedicine and in-person models (Table 1). First, the team decided that the hospitalist should lead all RRT and Codes with the pediatric critical care physician in support. This differs from the model at the main campus where the pediatric critical care physician leads. The reasons for this included that a) communication was best when coming from the on-site hospitalist, b) the on-site hospitalist was able to physically examine the patient, c) team feedback showed a preference that the leader be on-site, d) belief that the on-site hospitalist would be in the room earlier than the pediatric critical care physician via telemedicine and therefore could provide leadership sooner, and e) the pediatric critical care physician might not always be immediately available due to the needs of patients at the main campus and/or technical issue with telemedicine. In an RRT, the critical care provider was available to suggest potential diagnostic or therapeutic approaches not previously considered, to help facilitate the initiation of two therapies not previously available at the satellite facility (high flow nasal cannula and continuous albuterol), and to begin the process of transferring the patient if it was agreed that was the best course of action. In a code, the intensivist provided help to the hospitalist, but did not serve as team leader. Second, there was strong consensus in the post-simulation debriefs that all communication to the team from the pediatric critical care physician should be through the hospitalist. The simulation sessions demonstrated that identifying who was "in charge" was an important driver of success, and that it was challenging for team members to know who to defer to when both the in-house hospitalist and pediatric critical care physician gave orders. Third, the pharmacist and/or the on-site critical care nurses should be responsible for the code cart and drawing up medicines as they are more efficient and familiar with the process as compared to other nurses who are less familiar with the code cart. Fourth, having a defined role within the team where a pharmacist or bedside nurse would remain logged into the Pyxis system increased efficiency of delivering the care plan developed by the team. Fifth, roles were defined specifically for documentation and defibrillator set up. Finally, the optimal positions of team members and equipment in the room was established to ensure effective use of the telemedicine video system. This was especially important with the hospitalist moving to the side of the bed, since when hospitalist stood at the foot of the bed (as per the base model) the pediatric critical care physician could not see their face, which negatively affected communication (7). When the hospitalist and intensivist could see each other's faces, there was less confusion or redundancy in communication and an improved sense of teamwork. The defibrillator also was moved so that the pediatric critical care physician could see the screen to help assist with rhythm recognition.

Efficacy and Safety

The new unit opened in August, 2015. During the first 12 months of operations, there were 77 activations for RRT and 6 Code activations. The pediatric critical care physician participated in the RRT 100% of the time, 76/77 by telemedicine (98.7%); due to technical issues pediatric critical care physician support was provided by telephone once. Data concerning the RRT response time (the time between RRT called and pediatric critical care physician available by telemedicine) was available for 74 cases. The average response time was 8.4 minutes, with a median of 7 minutes and range of 0–23 minutes; in 70 of 74 (94.6%), the pediatric critical care physician was present within the goal of 15 minutes. Internal evaluation of our RRT response time at the base campus yielded similar results with an average response time of 7 minutes, and a range of 4 to 25 minutes. Of the 77 total RRT's, 35 (45.5%) stayed at the satellite campus, which is similar to the main campus RRT transfer rate to PICU of 42.9% (p= 0.72, Table 2). For the Code activations, data was available for all 6 cases (100%), with the PICU present within 7 minutes each time (mean 2.44 minutes, median 1.5 minutes). Three of the 6 (50%) stayed at the satellite campus.

At the CCHMC main campus, patients who are transferred to the PICU and require a significant escalation of care within one hour of transfer (defined as intubation, >60 ml/kg of fluid resuscitation, or initiation of vasopressors), are classified as Emergency Transfers. Over the time period where data was collected from the satellite campus, the main campus averaged 1.6 Emergency Transfers per month (978 total RRT activations, 20 total Emergency Transfers over 12 months, range 1–4 Emergency Transfers per month). Over that same period, the satellite campus had 0 patient transfers that met Emergency Transfer criteria (77 activations). A Fisher's exact test was performed and no difference was found in the number of patients meeting Emergency Transfer criteria between the two models (p=0.39, Table 2). There were 6 code activations at the satellite campus over that time, only 3 of which met our code definition due to acute respiratory compromise requiring active respiratory support. For 2 of the codes, CPAP was initiated. For the other code, the patient was electively moved to the satellite center Emergency Department and intubated.

Discussion

In order to improve access to subspecialty pediatric resources, large pediatric centers are increasingly developing satellite facilities to better meet the needs of the diverse geographic catchment areas they serve. These facilities employ a variety of staffing models, and critical care pediatricians are not always present onsite. In addition, many community hospitals with inpatient pediatric units do not have on-site pediatric intensivist support. This presents a unique challenge - how do these satellite facilities and community hospitals provide and maintain safe pediatric care without the readily available pediatric critical care physician resources that are present at larger campuses? Improvements in audiovisual communications and the subsequent development of telemedicine provides one potential answer to this question. Our findings suggest that with proper training and learning through simulation, critical care support of RRT and code teams may be as efficient, reliable, and safe as in-person support.

Telemedicine is an established technology with a growing body of data regarding efficacy. In pediatrics, Yager and colleagues found that cardiovascular and neurological assessments can be reliably done by telemedicine (15). Robison and Slamon utilized a mobile video interface to start the RRT within a children's hospital. In this model, where the intensivist later physically came to the bedside, telemedicine improved the speed with which the RRT responds without changing patient outcomes (16). Our findings are consistent with those findings, but importantly we found that a fully telemedicine model also achieved excellent efficacy and safety outcomes. Pediatric critical care physician telemedicine consultation by emergency medicine rooms has been well studied. Dayal *et al* showed that pediatric critical care physician consultation through telemedicine to emergency departments led to patients being less ill overall when admitted to the PICU than children admitted from emergency rooms without telemedicine (17). Telemedicine also led to a higher quality of care for pediatric patients in rural emergency rooms who have access to telemedicine as opposed to phone consultation (18, 19). Telemedicine consultation reduced medication errors in rural emergency departments treating pediatric patients (20). Although less literature exists on telemedicine interactions between pediatric critical care physicians and pediatric hospitalists, the implementation of telemedicine consultations between pediatric critical care physicians at a tertiary facility and pediatric hospitalists at a community facility improved triage and led to a lower rate of transfers of patients to the tertiary facility (21). Our findings showed a similar rate of transfer to a higher level of care when compared to our in-person model at our base facility. In addition, of those patients who were transferred using the telemedicine model, we found a similar proportion requiring significant escalation of care after transfer compared to our base campus model. The use of telemedicine by pediatric critical care physicians also improved health resource utilization by reducing the number of unnecessary transfers to tertiary and quaternary care center PICUs (22, 23).

During the development and establishment of satellite campuses without pediatric critical care physician support, several key processes must be established. First, a rubric must be established to identify which patients are eligible for safe admission to these facilities and which patients would be better served at a base facility with an easily accessible PICU. Second, a strategy should be developed for the monitoring of admitted patients for possible clinical deterioration. Finally, a process should be developed to consult pediatric critical care physician support, develop an escalation of care plan, and if necessary, arrange for safe transfer of the patient to the main campus for further care. Telemedicine has potential utility in all three phases discussed above. Our aim was to utilize telemedicine to specifically address the third process.

Although a successful RRT model at a main campus may provide a foundation for the establishment of a telemedicine RRT process at a satellite campus, differences in the two settings and the unique features of the telemedicine process make it unlikely that the base RRT model can be exactly replicated. With that in mind, our team sought to utilize simulation to identify how the team should function. Through simulation, we identified many key opportunities for improvement that allowed us to adapt the base model into a safe and efficient process carried out by telemedicine. Although the initial simulation period is complete, ongoing simulation is still occurring to further refine and improve this process and onboard/train new clinicians.

In the previous model at our satellite facility, no RRT or code team existed. The patients that were consider for admission were selected to be very low risk. The unit was physically adjacent to the emergency department and all patients who showed signs of clinical deterioration were taken to the emergency department and ultimately transferred to the base PICU. The new telemedicine system opened the possibility of patients who previously would have transferred remaining at the satellite facility for further management. In implementing such a change, a comparable or improved standard of care must be maintained. One of the first metrics that should be established in the development of telemedicine RRTs is that the team is able to efficiently and consistently respond. In addition to assessing if telemedicine can be utilized efficiently and consistently, the safety of this process must be determined. Our satellite campus telemedicine experience thus far has shown that a similar standard to our base campus model can be met utilizing telemedicine. In addition, we found telemedicine to be a reliable interface, with only one technical malfunction occurring during the study period.

This study does have several limitations. As a single center study, the data may not be generalizable across different systems. The implementation of the new model at our satellite campus occurred during a planned physical expansion of that facility. This provided a natural opportunity to appropriately plan for the physical and staff make-up of the new units. Most notably, it provided an opportunity to introduce two critical care qualified nurses to the daily nursing staffing. In facilities with existing units, staff re-organization to accommodate RRT and code teams may not be possible, and the physical structure of a given unit and cost of installing a telemedicine system may not make retrofitting a unit to have telemedicine capabilities feasible. An additional limitation this larger change in the care model introduced is that we did not have a natural pre- post comparison through which to evaluate the effect of the telemedicine intervention. Also, although our study demonstrated comparable safety, reliability, and efficiency to our base campus process, we did not evaluate staff feelings and attitudes towards the telemedicine process. We also lack data regarding 4 RRT activations where response times were longer than 15 minutes. In order to ensure long term success, this should be monitored and concerns should be addressed through quality improvement endeavors. Finally, although RRT activation was common during the study period, code activation was not. This makes it difficult to draw any strong conclusions regarding the effectiveness of the telemedicine model in improving code team efficacy.

Our experience has shown that telemedicine assessment by a pediatric critical care physician is one feasible and reliable model to promote safe and efficient expansion of pediatric institutions to satellite facilities that do not have pediatric critical care physician services. In addition, we believe that simulation provides a mechanism to define and refine the makeup and process of the telemedicine RRT. Going forward, we anticipate that the continued utilization of intermittent simulation will further improve this process. In addition, as our data set from the satellite campus RRT and code process continues to increase, we will be able to further determine opportunities for safety improvements.

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Table 1.

Team composition of RRT and Code teams at the main, academic campus versus the satellite facility without dedicated pediatric intensivists

Role	Main Campus RRT	Satellite RRT	Main Campus Code Team	Satellite Code Team
Physician lead	PICU fellow or attending	Hospital medicine attending	PICU fellow or attending	Hospital medicine attending
Nurse lead	Critical care RN1	Floor manager RN	CC RN 1	Floor manager RN
Code cart RN 1	-	-	Cardiac ICU RN	ED RN1
Code cart RN 2	-	-	CC RN 2	CC RN 1
Pharmacist	-	-	PharmD (day shift only)	PharmD (day shift only)
Medicine administration nurse	-	-	ED RN	Floor RN 1
ED paramedic	-	-	All shifts	When available
RT	RT 1	RT 1	RT 1 and 2	RT 1 and 2
Bedside assessment, order entry	-	-	Resident 1	Advanced practice nurse
Airway physician	-	-	Resident 2	ED or anesthesia attending
Intraosseous placement or defibrillator	-	-	Resident 3	APRN or floor manager RN
Chest compressions	-	-	Resident 4, 5, and 6	Floor RN 2, 3, and 4, paramedic
Manager of patient services	All shifts	All shifts	All shifts	All shifts
Chaplain	All shifts	When available	All shifts	When available

APRN, advance practice nurse; CC critical care; RN, registered nurse; RT, respiratory therapist, -, not applicable

Table 2.

Comparison of emergency transfers between the in-person RRT model at the main, academic center versus the telemedicine model at the satellite facility

	Base RRT (n=978)	Satellite RRT (n=77)	p value
Total transfers to the PICU	420	35	0.72
Emergency transfers	20	0	0.39