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Creation of a dedicated line team for critically ill patients with COVID-19: A multidisciplinary approach to maximize resource utilization during the COVID-19 pandemic

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Abstract

Background: Pandemics create challenges for medical centers, which call for innovative adaptations to care for patients during the unusually high census, to distribute stress and work hours among providers, to reduce the likelihood of transmission to health care workers, and to maximize resource utilization.

Methods: We describe a multidisciplinary vascular access team's development to improve frontline providers' workflow by placing central venous and arterial catheters. Herein we describe the development, organization, and processes resulting in the rapid formation and deployment of this team, reporting on notable clinical issues encountered, which might serve as a basis for future quality improvement and investigation. We describe a retrospective, single-center descriptive study in a large, quaternary academic medical center in a major city. The COVID-19 vascular access team included physicians with specialized experience in placing invasive catheters and whose usual clinical schedule had been lessened through deferment of elective cases. The target population included patients with confirmed or suspected COVID-19 in the medical ICU (MICU) needing invasive catheter placement. The line team placed all invasive catheters on patients in the MICU with suspected or confirmed COVID-19.

Results and conclusions: Primary data collected were the number and type of catheters placed, time of team member exposure to potentially infected patients, and any complications over the first three weeks. Secondary outcomes pertained to workflow enhancement and quality improvement. 145 invasive catheters were placed on 67 patients. Of these 67 patients, 90% received arterial catheters, 64% central venous catheters, and 25% hemodialysis catheters. None of the central venous catheterizations or hemodialysis catheters were associated with early complications. Arterial line malfunction due to thrombosis was the most frequent complication. Division of labor through specialized expert procedural teams is feasible during a pandemic and offloads frontline providers while potentially conferring safety benefits.

Keywords

Techniques and procedures, intensive care, catheters, dialysis access, nursing, economics and health services

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Introduction

The growing coronavirus disease 2019 (COVID-19) outbreak in the United States has gravely challenged critical care capacity.[1] An important is the ability to adequately staff intensive care units and exposure to illness of frontline intensive care unit physicians.[2] Effective management of critically ill patients infected with COVID-19 depends on the efficient provision of evidence-based care.[3] Ensuring frontline medical staff's safety and resilience while expanding pandemic-related surge capacity is an essential component of disaster preparedness.[1]

In preparation for an expected surge of critically ill COVID-19 patients admitted to our intensive care units, separate teams were developed for airway management and invasive line placement in this patient population. The goals of the COVID-19 line team were to:

1. Provide safe and maximally efficient invasive procedures to this critically ill patient group performed only by highly experienced and technically excellent physicians.
2. Provide a means to "off-load" the medical ICU primary providers to maximize their time to focus on other essential elements of caring for the critically ill and expanding their census.
3. Reduce exposure of medical ICU primary physician providers to infected patients in the hopes of limiting COVID-19 infection to this critical group of health care workers.

The concept behind the COVID-19 line team was to organize a group of voluntary, experienced group of experts from a variety of specialties who would perform all central venous and arterial catheter insertions for any patient diagnosed or suspected (persons under investigation (PUI)) of having COVID-19.

Methods

This study describes a successful ongoing collaboration between multiple disciplines supported by institutional leadership amidst the COVID-19 pandemic leading to the creation of a COVID-19 line team to assist with the insertion of central venous catheters, hemodialysis catheters, and arterial catheters in adult and pediatric ICU patients with confirmed or suspected COVID-19 infection. Experienced physicians were recruited from specialties, where invasive line placement is standard. Special consideration was given to specialties with decreased clinical demand due to reduced elective cases throughout the pandemic (Table 1).

A 24 h/day, 7 days/week call schedule was created and made available to all ICU directors and nursing leadership. A minimum of three team members were on call and readily available during the day and two at night with added redundancy for back-up in case of a patient surge. Attempts were made, when possible, to perform line placement 2–3 h after intubation to minimize team member exposure to aerosolized viral particles. All team members were trained (see below) in proper donning and doffing procedures before their first case, and to date, all cases have been performed using powered air-purifying respirators (PAPRs). To minimize the time in the room and bedside nurse demands, all team members prepared their sterile table (with everything needed for the procedure) outside the room, and entered the room, gowned and gloved, with a fully prepared table and portable vascular ultrasound machine. Catheter type and access site were planned through a multidisciplinary discussion between critical care physicians, critical care nurses, and COVID-19 line team members. Sedation and neuromuscular blockade were administered based on the primary team and expert's mutual decision. A shared Box (HIPPA compliant secure content management platform, Box. Inc, CA) folder was created where each team member recorded procedures and had access to share documents about best practices.

Table 1. Composition of the COVID-19 line team.

Subspecialty	Number of physicians
Anesthesiology	8
Procedure center	5
Pediatric critical care medicine	3
Cardiology	1

Role of simulation

Two simulation sessions were held with rapid cycle deliberate practice to outline steps of line placement unique to the COVID-19 patient. Within 4 days of the recruitment of team members, a meeting was convened to discuss schedule and equipment preferences and simulate steps of sterile catheter insertion in potential COVID-19 ICU rooms. Particular attention was paid to the complex process of donning and doffing and how it might impact line placement in this group of patients. A standard approach to setting up the room (i.e., location of the ventilator, sterile table, vascular ultrasound, medication pumps, etc.) with identification of the minimum personnel needed during the procedures was formulated and adapted in a simulated ICU room.

Workflow enhancement

The first several procedures were observed by as many team members as feasible and filmed for teaching purposes. Within 24 h of team activation, an instructional video was edited and uploaded to the shared Box folder described in methods detailing various procedural steps,

Table 2. Description of the procedures performed by the COVID line team.

Type of line	Percentage ($n = 145$)	Location (percentage)
Central venous catheters	48 (33.1%)	Internal jugular (81) Femoral (6) Peripherally inserted central catheter (12)
Arterial lines	80 (55.2%)	Radial (85) Femoral (12) Axillary and Brachial (3)
Non-tunneled hemodialysis catheters	17 (11.7%)	Internal jugular (82) Femoral (17)

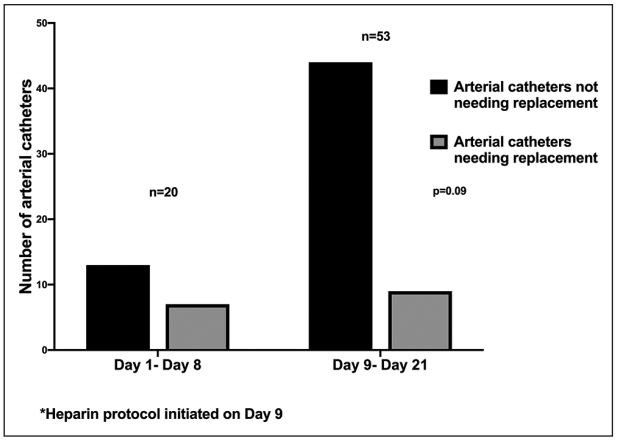

Figure 1. Arterial line replacement rate in the first 8 days of the team establishment compared to subsequent 13 days after heparin protocol initiation.

for example, setting up sterile equipment, donning and entering the room, communication with bedside nurse inside the room, room setup, the performance of the procedure, doffing and room exit. From the onset of team establishment, open dialog among line team members was initiated (group chat) to address, in real-time, issues with equipment availability, personal protective equipment, staffing, and approach to lines.

Records

A record of procedures performed was maintained and updated in real-time in the shared Box folder. Data points collected included procedural date, medical record number, location, the procedure performed, the team member performing procedure, patient COVID-19 status (positive or pending at the time of the procedure), and time spent in the room. An IRB approval was obtained for the study. A summary of the data collection is shown in Table 2. Data points collected were expanded (e.g., heparin added to the arterial line, time spent outside the room, etc.) as part of a continuous performance improvement process (see below).

Quality improvement measures

In addition to real-time group chats, COVID-19 line team members organized and participated in "line team" rounds with ICU medical team members every morning to streamline daytime workflow. Weekly team meetings (often attending via Webex, Cisco Inc, USA) were held to address issues impacting our performance. Specific areas addressed included but were not limited to (1) volume and distribution of lines, (2) logistical challenges, (3) coverage challenges, (4) individual exposure, and (5) specific areas of concern. As an example, one week following team activation, a high incidence (35%) of arterial line catheter failure was noted. Review of our prospectively gathered data demonstrated no clear association with equipment choice or operator. Emerging COVID-19 literature suggesting a high incidence of hypercoagulability[4,5] in this population facilitated rapid team consensus to add a heparin flush protocol to all patients receiving arterial lines (Figure 1). The difference in proportions of arterial line malfunction did not show a statistical difference before and after the intervention (heparin initiation on day 9, $p = 0.09$ by Chi-square test). Over 3 weeks, we had placed 145 invasive catheters (Table 2) with 45 operator hours inside the rooms of intubated ICU patients (times for lines and combination of lines in Table 3(a) and (b) respectively), minimizing exposure to the primary teams and improving their workflow significantly. Out of the 67 patients in these 3 weeks, 90% of patients required arterial catheters, 64% required central venous catheters, and 25% required hemodialysis catheters. Another important focus of this performance improvement initiative was closely monitoring individual team member exposure to these potentially contagious patients (70% of the patients were COVID-19 positive by PCR). These cumulative numbers were shared with the team at each weekly meeting with an emphasis on attempting to attain equal numbers among all team members (range 50–350 min, mean 147 min, and median 169 min).

Role of leadership and direction

The leadership of the COVID-19 line team had to strike a balance between providing patient care while assessing the risk profile and keeping the safety of the team in mind. The allocated resources were prudently distributed, and steps were taken to optimize valuable resources such as personal protective equipment. The secondary benefit was coverage expansion of the critical care teams[1] to care for a higher number of ICU patients (one attending and fellow providing care to up to 20 ICU patients after the COVID-19 line team was functioning) due to reduction in time engagement with invasive catheter placements. The

Table 3. (a) Time spent in the room for different groups of catheters.

Line type	Average (minutes)	Median (minutes)	Minimum (minutes)	Maximum (minutes)	Interquartile range (1–3)
Central venous catheter	21	20	8	50	15–25
Arterial catheter	18	15	5	45	10–22
Hemodialysis catheter	24	20	10	60	15–22

(b) Time spent in the room for different combinations of catheters.

Combined line type (occurrences)	Average (minutes)	Median (minutes)	Minimum (minutes)	Maximum (minutes)	Interquartile range (1–3)
CVC + Aline (31)	37	33	20	60	30–48
HD + Aline (4)	38	33	25	65	29–42
CVC + Aline + HD (6)	44	44	40	50	41–45

CVC: central venous catheter; Aline: arterial catheter; HD: hemodialysis catheter.

coverage before COVID-19 was a maximum of 15 patients per team, with an average of 10 patients in the preceding 3 months.

Discussion

Health care workers working at the frontline have an elevated risk for severe infection or death if they become infected with COVID-19.[6,7] It is not possible to entirely eliminate risk, but prudent adjustments maybe warranted.[2,3] Multidisciplinary teams are increasing in healthcare.[8,9] Organizations are utilizing innovative ways to deploy experts like those described in this study to form expert teams.[9–11] This would provide expertise and limit stress on the clinical overload that the primary teams have in taking care of the COVID-19 patients and improving this vulnerable group of patients.[3] It is also true that experts may not necessarily combine to make an expert team. However, when teams work well, they can serve as adaptive systems that allow organizations to mitigate errors within complex domains, thereby increasing safety demonstrated by no early complications of the catheters performed by the COVID-19 line team as our approved study duration was for the 3 weeks.[12] In a unique milieu such as the COVID-19 pandemic, our study emphasizes just in time creation of the COVID-19 line team using the "big five" of teamwork,[8] theories adapted from the military and aviation industry. Team leadership was an integral part of execution with the establishment promptly, communicating current best practices clearly and compassionately through the weekly meetings, managing expectations and providing sufficient resources and adequate personal protective equipment, and synchronizing team member contributions.[7] Importantly, this was done proactively to reduce the exposure of the trainees (fellows and residents) and reducing cognitive and psychological workload. Back up provider behavior and flexibility in the schedule were vital as outside commitments of the team members varied. Team orientation and mutual performance monitoring were enhanced through simulation sessions to identify opportunities for improvement for habitual practices (e.g., preparing a sterile equipment table outside the room- not a common practice), yielding the ability to remain vigilant and develop shared understandings of the team environment (ergonomics of the space, efficient ways of communicating with PPE) and applying appropriate task strategies to accurately monitor teammate performance (donning and doffing PPE appropriately) when feasible.

Recommendations and consensus guidelines on airway management in the COVID19 patient are available,[13,14] and although obtaining vascular access does not constitute an aerosolizing procedure, it increases the risks of hazards including pathogen exposure, long working hours, psychological distress, and fatigue.[15] To our knowledge, this is one of the first reports of an innovative approach to resource utilization and collaboration between different services to establish a well-functioning team to obtain vascular access in the COVID-19 population. This model (along with other specialized teams) allows hospitals to expand ICU services using qualified experienced practitioners who may be potentially otherwise under-utilized in this crisis, thereby preserving and maximizing the well-being, resilience, and efficiency of the ICU team.

Authors' note

The Institutional Review Board at Cedars-Sinai Medical Center approved this study.

Declaration of conflicting interests

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