Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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The Boston Medical Center Coronavirus Disease 2019 (COVID-19) Procedure Team: Optimizing the surgeon's role in pandemic care at a safety-net hospital

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ABSTRACT

Background: The coronavirus disease 2019 pandemic has claimed many lives and strained the US health care system. At Boston Medical Center, a regional safety-net hospital, the Department of Surgery created a dedicated coronavirus disease 2019 Procedure Team to ease the burden on other providers coping with the surge of infected patients. As restrictions on social distancing are lifted, health systems are bracing for additional surges in coronavirus disease 2019 cases. Our objective is to quantify the volume and types of procedures performed, review outcomes, and highlight lessons for other institutions that may need to establish similar teams.

Methods: Procedures were tracked prospectively along with patient demographics, immediate complications, and time from donning to doffing of the personal protective equipment. Retrospective chart review was conducted to obtain patient outcomes and delayed adverse events. We hypothesized that a dedicated surgeon-led team would perform invasive bedside procedures expeditiously and with few complications.

Results: From March 30, 2020 to April 30, 2020, there were 1,196 coronavirus disease 2019 admissions. The Procedure Team performed 272 procedures on 125 patients, including placement of 135 arterial catheters, 107 central venous catheters, 25 hemodialysis catheters, and 4 thoracostomy tubes. Specific to central venous access, the average procedural time was 47 minutes, and the rate of immediate complications was 1.5%, including 1 arterial cannulation and 1 pneumothorax.

Conclusion: Procedural complication rate was less than rates reported in the literature. The team saved approximately 192 hours of work that could be redirected to other patient care needs. In times of crisis, redeployment of surgeons (who arguably have the most procedural experience) into procedural teams is a practical approach to optimize outcomes and preserve resources.

Introduction

At the time this report was written, Massachusetts ranked third in total cases of coronavirus disease 2019 (COVID-19) in the United States.[1-3] As a safety-net hospital, Boston Medical Center (BMC) cares for our city's most vulnerable patients, and, as expected, we have been impacted disproportionately. During early April 2020, 7 of 10 patients admitted were ill from COVID-19, many of whom required care in the intensive care unit (ICU).[4,5] After cancelling all non-urgent operations, the Department of Surgery restructured and consolidated its surgical services. These measures were intended to preserve hospital capacity for the anticipated surge of patients, to conserve personal protective equipment (PPE), to protect house officers and faculty, and to maintain a reserve of healthy personnel as other frontline colleagues potentially fell ill. A dedicated Procedure Team was created and, as of the date of manuscript submission, continued to perform invasive, bedside procedures on all COVID-19 patients. Our goal was to perform these procedures expeditiously with high success rates, decreasing adverse outcomes, limiting clinician exposure to COVID-19, and decreasing use of valuable PPE, which was often in short supply.

This short-term follow-up study has the following 3 aims: (1) describe the number and types of procedures performed by the

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Procedure Team, (2) quantify and assess outcomes, and (3) extrapolate lessons for other institutions that may need to establish a similar team in a short timeframe. These data add to the COVID-19 literature by describing a mechanism through which surgeons can effectively use their skills in the current pandemic—particularly as hospitals brace for a possible second COVID-19 surge when restrictions on social distancing are lifted—and potentially in future acute disruptions to health care systems and hospitals.

Methods

The COVID Procedure Team comprises an attending surgeon and 2 senior surgery residents. As the number of COVID-19 cases increased in the hospital, surgeons in the Section of Trauma and Acute Care Surgery were deployed full time to the ICUs, and the noncritical care surgeons now staff 2 inpatient surgical teams. The "non-admitting" surgical team (alternating daily) is the Procedure Team for that day and is available 24 hours per day. Training sessions for ultrasonographically guided central venous catheter (CVC) insertion were led by a critical care surgeon and conducted via Web conferencing and in the BMC Simulation Center. A dedicated supplies cart and portable ultrasound machine were utilized. Residents on the team were responsible for restocking the cart. The team tracked prospectively all procedures in a database for purposes of quality control and resource planning.

The BMC Institutional Review Board approved this retrospective chart review for all patients who underwent procedures during the team's first month (March 30, 2020–April 30, 2020), including demographics, comorbid conditions, and hospitalization details. Adverse events that occurred after catheter placement, referred to as "delayed events," were captured, including catheter dislodgement, catheter-associated infection, and catheter thrombosis. Catheter-associated infection was defined according to standard guidelines of the Centers for Disease Control.[6] Association of complications and postgraduate year (PGY) level (PGY3 versus PGY4 versus PGY5) was assessed using analysis of variance.

Results

During the 1-month study period, 1,196 patients required hospitalization at BMC for confirmed or suspected COVID-19, accounting for more than 75% of the daily admissions during Boston's COVID-19 "peak." About 10% of these patients ($n = 125$) required 272 invasive bedside procedures by the Procedure Team. Demographics and comorbid conditions are detailed in Table I. The mean number of procedures per patient was 2.2, with 91% of patients undergoing more than 1 procedure.

A total of 135 arterial catheters, 107 CVCs, 25 hemodialysis catheters, and 4 thoracostomy tubes were placed. Arterial catheters were placed generally in radial arteries (92%) and—to a lesser extent (6%)—in the femoral arteries. Axillary arterial catheters were placed in specific situations when extensive vascular interventions precluded use of the femoral artery. CVCs were placed for the most part in the internal jugular (IJ) vein (55%), followed by subclavian (37%) and femoral (8%) veins. Regarding hemodialysis catheters, 60% were placed in the IJ veins and 40% in femoral veins. Thoracostomy tubes were placed in 4 patients for pneumothoraces (1 iatrogenic) (Table II).

The rate of immediate complications among the placement of all CVCs and hemodialysis catheters was 1.5%. One patient developed a pneumothorax after subclavian CVC placement. Another patient required emergency vascular repair after a through-and-through injury of the IJ vein and subsequent carotid artery cannulation after an attempted ultrasonographically guided CVC placement. Delayed events were identified in 15% of patients, including catheter thrombosis (29 arterial catheters, 7 CVCs, and 1 hemodialysis catheter). No catheter-associated infections were identified. Failed attempts occurred in 7% of arterial catheters and 6% of CVCs. We observed no association between resident PGY level and complications ($P = .98$). To our knowledge, no Procedure Team members have developed COVID-19.

Of the 272 procedures, we timed 168 procedures (donning of PPE to doffing). Average procedural time was 39 minutes for arterial catheters, 47 minutes for CVCs, and 49 minutes for hemodialysis catheters. Whenever safely possible, concurrent arterial lines and CVCs were performed simultaneously by 2 residents; average time for concurrent procedures was 55 minutes. Of the 125 patients treated by the Procedure Team in April 2020, 80 have achieved final disposition, involving 41 deaths and 39 discharges. Hospitalization details are included in Table III.

Discussion

COVID-19 has challenged the US health care system and, in many ways, overwhelmed its resources. Our institution reorganized to maximize capacity for COVID-19 patients in one of the hardest-hit cities in the United States. Among other efforts, the BMC Department of Surgery created a COVID-19 Procedure Team, which was formally integrated into our institutional response to the pandemic.

The BMC COVID-19 Procedure Team performed 272 procedures in 125 patients in 1 month. This required approximately 192 hours of work (equivalent to 16 shifts of 12 hours). These were extremely ill patients, as evidenced by the 93% ICU admission rate and 87%

Table I
Demographics and comorbid conditions of patients ($n = 125$) treated by the Procedure Team

Mean age, y (range)	61 (19–92)
% Female (*n*)	30 (38)
Mean BMI (range)	32 (17.8–93.1)
Race, % (*n*)	
Black/Non-Hispanic	47 (59)
Black/Hispanic	19 (24)
White	22 (27)
Asian/Pacific Islander	2 (2)
Unknown	10 (13)
Homelessness, % (*n*)	9 (11)
COVID-19 positive, % (*n*)	76 (95)
Comorbidities, % (*n*)	
DM	47 (57)
CAD/CHF	29 (36)
HTN	58 (73)
Asthma	8 (10)
COPD	10 (13)
ESRD	6 (7)
CKD	13 (16)
PAD	6 (8)
Immune compromise	4 (5)
Smoking status, % (*n*)	
Never	42 (52)
Current	17 (21)
Former	35 (44)
Presenting Location, % (*n*)	
Home	75 (94)
SNF/Rehab	10 (13)
Homeless	9 (11)
Transfer from OSH	5 (6)
Other	1 (1)

BMI, body mass index; *DM*, diabetes mellitus; *CAD/CHF*, coronary heart disease/congestive heart failure; *HTN*, hypertension; *COPD*, chronic obstructive pulmonary disease; *ESRD*, end-stage renal disease; *CKD*, chronic kidney disease; *PAD*, peripheral arterial disease; *SNF*, skilled nursing facility; *OSH*, outside hospital.

Table II
Procedural details

Total procedures	272
Mean procedures/patient (range)	2.2 (1–7)
% Patients with >2 procedures (*n*)	14 (38)
% Patients undergoing 2 simultaneous procedures (*n*)	17 (45)
Time of procedure, % (*n*)	
Day (6 AM–6 PM)	45 (118)
Night (6 PM–6 AM)	55 (143)
Patient location at time of procedure, % (*n*)	
non-ICU	3 (8)
ICU	97 (264)
% Arterial catheter (*n*)	50 (135)
Location, % (*n*)	
Radial	92 (124)
Femoral	6 (8)
Axillary	2 (3)
Complications, % (*n*)	
Vascular Injury	0 (0)
Line Infection	0 (0)
Line Thrombosis	22 (29)
% Central venous catheter (*n*)	39 (107)
Location, % (*n*)	
Internal jugular	55 (59)
Subclavian	37 (40)
Femoral	8 (8)
Complications, % (*n*)	
Pneumothorax	0.9 (1)
Vascular injury	0.9 (1)
Line infection*	0 (0)
Line thrombosis	7 (7)
% Hemodialysis catheter (*n*)	9 (25)
Location, % (*n*)	
Internal jugular	60 (15)
Femoral	40 (10)
Complications, % (*n*)	
Pneumothorax	0 (0)
Vascular injury	0 (0)
Line infection	0 (0)
Line thrombosis	4 (1)
% Chest tubes (*n*)	2 (4)

*The 2 positive catheter tip cultures were attributed to contamination because neither patient had a blood stream infection as evidenced by negative blood cultures.
ICU, intensive care unit.

Table III
Details of hospitalization and patient outcomes

Admission disposition	
% Non-ICU (*n*)	44 (55)
% ICU (*n*)	56 (70)
% Required transfer to ICU (*n*)	93 (51)
Mean time to ICU transfer, h (range)	72 (6–388)
% ICU readmission (*n*)	5 (6)
% Intubated (*n*)	87 (109)
Mean time to intubation, h (range)	52 (0–454)
% Ventilated prone (*n*)	44 (55)
% New dialysis (*n*)	27 (34)
Inpatients with CKD	21 (7)
Inpatients with ESRD	18 (6)
Inpatients with no previous CKD/ESRD	62 (21)
% Discharged (*n*)	64 (80)
Discharge disposition, % (*n*)	
Deceased	51 (41)
Home	21 (17)
SNF/rehab	10 (8)
OSH	8 (6)
Shelter	6 (5)
Hospice	4 (3)
Duration of stay, days (range)	
ICU	9 (0.3–41)
Hospital	13 (0.6–37)

ICU, intensive care unit; *ESRD*, end-stage renal disease; *CKD*, chronic kidney disease; *SNF*, skilled nursing facility; *OSH*, outside hospital.

intubation rate (44% ventilated prone). The Procedure Team decreased clinician exposure and promoted expertise with donning and doffing of PPE, conserving those supplies and minimizing provider infections.[7] The procedural complication rate for central venous and hemodialysis catheters was 1.5%, which is substantially less than rates reported in the literature (3%–10%).[8] There was a single iatrogenic pneumothorax (0.9% of IJ and subclavian central venous and hemodialysis catheters), again less compared with rates in the literature (1.0–6.6%)[9], and a single arterial cannulation (0.8% of all central venous and hemodialysis catheters), similar to the rates of 0.1% to 1% reported in the literature.[10-12] The IJ veins were particularly favored for patients who were morbidly obese, had chronic kidney disease (to avoid central venous stenosis of the subclavian or brachiocephalic veins), or were receiving therapeutic anticoagulation. Subclavian CVCs were performed relatively frequently (37%) and became our preferred approach because they saved time and prevented potential cross contamination via the ultrasound machine. Subclavian access is also valuable in the setting of tracheostomies that might contaminate an IJ vein cannulation site. Whenever possible, the right IJ vein is preserved for hemodialysis catheters.

Initially, the thrombosis rate of arterial catheters was relatively high (22%), with many patients requiring multiple replacements. This is likely related to the thrombogenic nature of COVID-19 infection.[13-15] In response, we implemented continuous infusions of dilute heparin (2 units/mL, infused at a rate of 3 mL/h) as supported by studies demonstrating prolonged catheter patency and lesser rates of thrombosis compared with normal saline.[16-18]

Several lessons have been gleaned from this experience. Departmental restructuring was necessary to produce the workforce required to consistently staff the Procedure Team. This process required engagement by all nontrauma attending surgeons, which was easily accomplished in our department. These procedures were not considered teaching cases, and we limited their performance to senior-level residents, thus limiting provider exposure and conserving PPE. The team utilized its own equipment and supplies without relying upon the ICU stockrooms, which allowed for uniformity of practice and minimized the need for entering and exiting the room during procedures. (Procedure carts remained outside the room.) We found that use of subclavian CVCs, unless contraindicated, decreased time in patient rooms. Safety was uncompromised, with no increase in complication rates. We found that few patients required tube thoracostomy placement.

This study has limitations. The study period was limited to 1 month, preventing us from tracking long-term outcomes. In addition, as a single institution study, the results may not be applicable to other centers. Nevertheless, our data support the practicality and value of rapidly implementing a surgeon-led, invasive procedure team during a pandemic when elective operations are halted. To our knowledge, there is only one other published report describing the implementation of such a team in response to the COVID-19 pandemic.[19] The data reported here, including procedural volume, time savings, and short-term outcomes, provide additional support for the feasibility and safety of this type of endeavor. As communities begin to lift measures of social distancing, health care institutions are bracing for a potential second surge of COVID-19 infections, and future acute disruptions to our usual care processes must be anticipated in this globalized world.

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Conflict of interest/Disclosure

The authors have no related conflicts of interest to declare.

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