Original Article

Rapid Expansion of the Airway Response Team to Meet the Needs of the COVID-19 Pandemic

Elisa C. Walsh • Jean Kwo • Marvin G. Chang • Richard M. Pino • Edward A. Bittner

ABSTRACT

Introduction: The COVID-19 pandemic has brought unprecedented numbers of patients with acute respiratory distress to medical centers. Hospital systems require rapid adaptation to respond to the increased demand for airway management while ensuring high quality patient care and provider safety. There is limited literature detailing successful system-level approaches to adapt to the surge of COVID-19 patients requiring airway management.

Methods: A deliberate system-level approach was used to expand a preexisting airway response service. Through a needs analysis (taking into account both existing resources and anticipated demands), we established priorities and solutions for the airway management challenges encountered during the pandemic.

Results: During our COVID-19 surge (March 10, 2020, through May 26, 2020), there were 619 airway consults, and the COVID airway response team (CART) performed 341 intubations. Despite a 4-fold increase in intubations during the surge, there was no increase in cardiac arrests or surgical airways and no documented COVID-19 infections among the CART.

Conclusions: Our system-level approach successfully met the sudden escalation in demand in airway management incurred by the COVID-19 surge. The approach that addressed staffing needs prioritized provider protection and enhanced quality and safety monitoring may be adaptable to other institutions.

Keywords: airway management, intubation, quality improvement, system-level approach, COVID 19

Introduction

The coronavirus disease 2019 (COVID-19) pandemic has brought unprecedented numbers of patients with hypoxia and acute respiratory distress to medical centers throughout the world.[1] These patients often require emergent tracheal intubation and mechanical ventilation. As a result, severe stresses are placed on medical systems that are often already resource constrained, with a disproportionate burden on academic medical centers.[2] Existing medical personnel and hospital systems require rapid adaptation to meet patient needs and ensure healthcare provider safety.

Although there is a growing body of literature on best practices for intubation of COVID-19 patients,[3-7] there is limited literature detailing the system-level changes used to adapt to the surge of patients requiring airway management and the impact of these changes on patients and providers including rate of cardiac arrests during emergency airway management, need for surgical airway, reintubation rates, and infection rates of members of airway response teams (ARTs). It is our hope that reporting successful system-level solutions from our institution and others will pave the way for collaboration and comparison between different centers, allowing for the development of best practices that can be used for future surges of COVID-19 and other pandemic illnesses.

Methods

The hospital's institutional review board approved this quality improvement study (IRB #2020P001934).

System-Level Design and Evolution

At the beginning of the pandemic, members of the Massachusetts General Hospital's ART performed a comprehensive analysis to assess capabilities and adapt

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the team for the anticipated number of COVID-19 patients that would require airway management. This needs assessment took into account the preexisting ART team practice, hospital-wide adaptations to account for the surge of COVID-19 admissions, staffing needs, protection of healthcare providers, availability of equipment and supplies, and monitoring of quality and safety of the practice during the pandemic. The implementation of system-level changes resulted in adaptation and expansion into the COVID ART (CART) service to accommodate the increase in demand for COVID-related patient consults while ensuring the highest level of care and safety for the patients and health care workers within our hospital. These system-level considerations and solutions are detailed below and summarized in Table 1.

Preexisting Airway Response Team

The ART service at MGH serves to provide coordinated and rapid intervention for airway emergencies, using clinicians with specialized training in airway management and critical care. In addition to performing intubations, the ART provides consultation on the need for intubation versus noninvasive airway support therapies and performing extubation readiness assessments. At the MGH, a 1000-bed tertiary care hospital in Boston, MA, the pre-COVID-19 ART consisted of an on-call critical care–trained anesthesiologist, critical care fellow, respiratory therapist, and anesthesia resident.[8] In addition, a senior surgical resident and trauma attending are available 24/7 if a surgical airway is needed. Such team-based systems have been shown to reduce the high rate of complications associated with emergency airway management.[9-11] The ART service performs intubations and consultation on the hospital wards, intensive care units (ICUs), and emergency department (ED) as needed.

The critical care–trained anesthesiologist covering ART has traditionally also covered a twenty-bed surgical ICU (SICU) with another intensivist during the day and as the sole intensivist at night and weekends. In the 3 months before the pandemic, the average number of ART consults was 3.6 per 24 hours period which was manageable for the critical care–trained anesthesiologist also covering the SICU.

Standardization of Intubation Practices of COVID-19 Airway Response Team

We standardized our intubation practice as described in the review by Sullivan et al.[4] In brief, videolaryngoscopy was encouraged for intubations during the COVID-19 pandemic given the increased distance of the provider from the airway allowing for potentially decreased exposure to members of CART. Before COVID-19, the predominant method of intubation was with direct laryngoscopy. Furthermore, vasopressors were readily available, in line with the patient, and often started before the induction of anesthesia given anticipation of hypotension in COVID-19 patients after induction of anesthesia for intubation. The CART team also performed interval respiratory rounds of COVID-19 patients throughout the hospital to anticipate patients at highest risk for rapid decompensation and difficult airways. Noninvasive ventilation and high flow nasal cannula was discouraged unless performed in a negative pressure room to minimize risk of aerosolization and exposure to healthcare personnel. COVID ART continued to have two providers for each intubation given our institutional experience with reduced complications when intubation is performed as a team of providers as opposed to a single provider.[12]

Hospital-Wide Adaptations

Based on the experiences in China and Italy, our institution anticipated that the number of COVID-19 patients admitted to the hospital would be unpredictable and potentially substantial.[13,14] To accommodate the projected surge, a number of additional patient wards and 4 additional ICUs were established for COVID-19 patients within our institution. These new units were adapted from existing patient care units and were geographically distributed throughout the hospital. Staffing for these "surge units" often relied on providers who were not primarily trained in critical care, anesthesiology, or internal medicine as well as healthcare providers from other institutions. These providers were often less familiar with assessment of respiratory decline, activation of the ART, providing assistance during airway management, and extubation practices.

Providers in the COVID ward and ICUs were educated regarding methods and criteria for activation of the CART service through the MGH emergency paging system. Pages were designated as "urgent" or "nonurgent" based on standardized criteria detailed in a recent review by Sullivan et al.[4] The CART activations by the paging system archives were monitored regularly to assess service demand over time. Specific parameters of interest included call type (intubation vs. consultation), location, and need for surgical airway backup.

Staffing Needs

Increased staffing needs were anticipated because of the surge in admissions for COVID-19, geographic dispersion of COVID-19 units, variable critical care

Table 1. System Level Priorities, Challenges, and Solutions for Rapid Expansion of the Hospital Airway Response Team

Priorities	Challenges	Solutions
Protection of healthcare providers	Ensuring adequate training Ensuring sufficient equipment and immediate availability Minimize risk of individuals at increased risk of illness Minimize fatigue/stress	Training (online and in person) Obtaining adequate equipment Dedicated equipment and sterilization procedures Minimizing the number of staff involved Monitoring for provider infection Minimize trainee involvement Voluntary participation
Staffing needs	Unpredictable number of patients Wider geographic distribution of patients within hospital Staff within surge units less familiar with ART service Ensuring providers are adequately trained for emergency airway management Ensuring backup if needed Expanded service needs (consults for assessment, monitoring, intubation, and extubation) Increased time required per intubation because of personal protective procedures	Adapt preexisting airway response team practices Employ board eligible/certified anesthesiologist with critical care fellow backup Standardization of intubation practice (e.g., drugs, equipment) Standardization of criteria for notification of the ART Dedicated "COVID" consult pager
Quality and safety monitoring	Rapid data/communication to assess needs Determining appropriate timing to de-escalation	Monitoring pager numbers and types of calls Twice-daily shift handoffs with known consults Safety reporting to Quality Assurance Registry

ART, airway response teams.

experience of providers staffing the surge units, and unpredictable severity of the COVID-19 illness. The number of CART activations and the amount of time invested in each activation (because of donning and doffing of personal protective equipment) both were expected to increase dramatically compared with presurge numbers. For these reasons, it was important to ensure the participation of experienced CART members to maximize the chance at first-pass intubation success and reduce complications in this vulnerable patient population. Furthermore, it was also important to ensure sufficient staffing numbers to minimize provider fatigue and allow for providers who may have to quarantine or recover because of contraction of the virus.

Protection of Healthcare Workers

Intubation is one of the highest risk procedures for viral aerosolization and exposure of healthcare workers.[15,16] To mitigate these risks, we needed to develop educational programs to educate CART members to reduce viral exposure both to themselves and other assisting providers. Furthermore, we needed to identify and exclude members with medical conditions that might place them at increased risk of contracting the disease.

Equipment Availability

It was essential to ensure that ART members had an adequate supply of standard airway equipment, medications, and supplies as well as the availability of difficult intubation equipment, particularly given the potential for large numbers of intubations and wide geographic distribution of patients. In addition, we anticipated that the team would need a system to ensure safe disposal and rapid sterilization of equipment after exposure to patients with COVID-19. Finally, it was important to ensure immediate availability of appropriate personal protective equipment (PPE) was necessary for all providers engaged in the ART.

Quality and Safety Monitoring

To monitor the quality of the CART practice and safety for CART providers during the pandemic, we

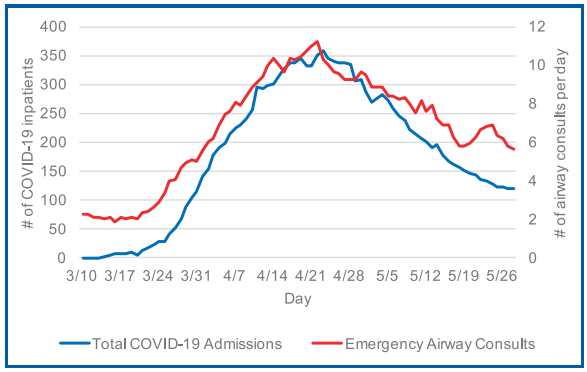

Figure 1. Airway consults versus in-hospital COVID-19 census from March 10, 2020, to May 26, 2020.

needed to develop a system with rapid access to data regarding the number and locations of COVID-19 admissions as well as robust communication with providers regarding the need for CART consultation and within the team itself. In addition, methods for determining the appropriate time for de-escalation of the practice and return to presurge staffing were needed. This was facilitated by analyzing data from CART consults including date and time of activation, location, and reason for activation that were collected from the paging records of the dedicated CART pager. Data regarding sentinel events including peri-intubation cardiac arrest and need for surgical airways were collected from the medical records and departmental quality assurance database. To examine the impact of provider engagement and development of viral exposure, an anonymous survey was performed.

Evolution of the COVID Airway Response Team During Pandemic

The CART consisted of a dedicated group of operating room (OR) anesthesiologists who were available because of reductions in surgeries and who volunteered for the role. During the surge, this group of anesthesiologists had no additional responsibilities while involved with the CART. The critical care anesthesiologists who previously participated in the ART developed guidelines to standardize intubation practice, and these guidelines were disseminated to the CART providers. Each anesthesiologist involved with the CART was partnered with an ICU fellow for assistance and back-up during consults. Benefits of this staffing solution were severalfold. First, it freed the critical care–trained anesthesiologist who typically staffed the ART service to exclusively focus his or her efforts on the care of COVID-19 patients in the ICU. In addition, it leveraged the expertise in airway management of OR anesthesiologists. Furthermore, it ensured airway management and critical care expertise and backup while limiting the number of providers engaged in the practice, thereby reducing potential viral exposure. Finally, the available pool of anesthesiologists was large enough to allow voluntary participation and provided sufficient numbers to allow scheduled breaks, thereby minimizing provider fatigue. It also allowed for CART participants who might have to quarantine or recover because of contraction of the virus. In addition, it eliminated the need for involvement of inexperienced trainees, thus increasing first-pass intubation success and reducing associated complications and potential COVID-19 exposure for the clinicians performing the intubation. The CART team members were scheduled to cover 12 hours shifts with time allotted to pass off. The pass off allowed introductions between team members and communication of patient and equipment-related issues.

Before engagement in the CART team, each anesthesiologist received standardized training both online and in person to ensure safe practice with donning and doffing PPE. To ensure immediate availability of equipment, the CART provider carried a standardized backpack with basic airway equipment including direct and video laryngoscopes, supraglottic airway devices, endotracheal tubes, positive end-expiratory pressure valve, colorimetric capnography, intubation bougies, and oral airways as well as resuscitative, sedative, and paralytic medications. All providers were equipped with PPE including face shields, fit-tested respirators (either N95 mask or a powered air-purifying respirator), fluid-resistant gown, head and shoe covers, and gloves. The in-house trauma surgery team continued to provide 24/7 surgical airway back-up. The CART service providers were monitored daily for symptoms of infection as part of hospital-wide protocol; if suspected, they were removed from the CART and underwent testing as indicated.

Results

Rapid Scalability of Service Provided by COVID Airway Response Team Service

The CART team was activated on March 10, 2020, and remained in use until May 26, 2020, when consultation numbers decreased to a level that allowed return to coverage by the preexisting ART team. Figure 1 displays the number of CART consults

per day during the surge superimposed on the number of hospitalized COVID-19 patients. The number of CART consults per day paralleled the number of COVID-19 inpatients suggesting that the number of inpatients could be used to predict the number of consults per day. The system-level implementations allowed the CART service to respond to a peak of 12 consults per day during the surge compared with 3.4 consults per day presurge. A total of 30 anesthesiologists and 12 ICU fellows participated in the CART service from March 10, 2020, until May 26, 2020, and responded to 619 consults and performed 341 intubations (Table 2). In addition to the increase in number of CART consults during the surge, the geographical distribution of consults was increased throughout the hospital (Figure 2). Among the COVID consults, the majority (59.7%) occurred in ICUs, 33.1% on patient wards, and 7.2% in the ED.

The number of CART consults at night increased during the surge to an average of 46.6% of consults during a 24-hour period compared with 34.7% before the surge (Figure 3). Based on this finding, we continued to staff the CART with a dedicated anesthesiologist 24/7.

Quality and Safety Monitoring

Increase in Reintubations During Surge

The reintubation rate during the surge was monitored given that reintubations are often associated with increased greater complications compared with initial intubation and may be more emergent in nature.[17] In addition, an increase in patients with COVID failing extubation had been reported.[18] We found that the number of reintubations increased from 9.6% before the surge to 14% during the surge.

No Increase in Surgical Airways During Surge

Failure to intubate was monitored during the surge because it is a life-threatening event associated with increased morbidity and mortality. During the COVID-19 surge (from March 10, 2020, through May 26, 2020), there were 4 calls for surgical airway backup, and no patients required emergent surgical airways, compared with 5 calls and 2 surgical airways performed from January 1, 2020, to March 10, 2020.

No Increase in Cardiac Arrests During Surge

Cardiac arrests associated with intubation are associated with increased mortality and therefore were also monitored as a safety measure.[19] During the surge, 2 patients (0.59%) experienced intubation-related cardiac arrests (i.e., within 30 minutes of intubation) compared with 1 patient (1.4%) before the surge. There were no deaths or severe adverse events (e.g., brain injury) directly attributed to intubation during the surge.

No Documented COVID-19 Infections in COVID Airway Response Team Providers

Anesthesiologists who participated in the CART were anonymously surveyed through email regarding the development of COVID attributable to their service.

Table 2. Comparison of Practice and Intubation-Related Complications Before and During the COVID-19 Surge

	Presurge (January 1, 2020–March 9, 2020)	Surge (March 10–May 26, 2020)
Consults (n)	259	619
Intubations (n)	72	341
Consults at night (5 PM–7 AM) (%)	34.7%	46.6%
Videolaryngoscopy use as initial intubation method (%)	24.8%	98%
Consult locations (%)	78% ICU; 17.2% wards; 4.8% ED	59.7% ICU; 33.1% wards; 7.2% ED
Intubation-related cardiac arrests (n/%)	1 patient (1.4%)	2 patients (0.59%)
Surgical airway calls/airways performed (n)	5 calls; 2 surgical airways	4 calls; 0 surgical airways
Reintubations (%)	9.6%	14%

ED, emergency department; ICU, intensive care unit.

The survey had 83.3% (25 of 30) response rate. Among the respondents, 8.0% (2/25) reported experiencing symptoms within 2 weeks of serving on the CART service, and 20.0% (5/25) were tested for COVID-19 by nasopharyngeal swab and underwent periods of quarantine. Among these providers, none reported testing positive for COVID-19.

Limitations

Institutions vary in size, staffing, and capacity. Whether the CART expansion model would be effective or efficient in a hospital with different characteristics or more limited resources is unknown. Both number and timing of patients admitted during the surge is also likely to be a factor in the success of any care model including a CART. The primary data source used in the analysis was obtained from paging records. It is possible that some patients received airway consultation and/or intubation or experienced airway complications that did not result in activation of the hospital's paging system.

Discussion

Our study shows that with the implementation of multiple system-level changes throughout our institution, we were able to successfully adapt our preexisting ART to meet the sudden escalation in demand for our ART incurred by the COVID-19 pandemic while providing high quality care with no increase in the rate of cardiac arrest and surgical

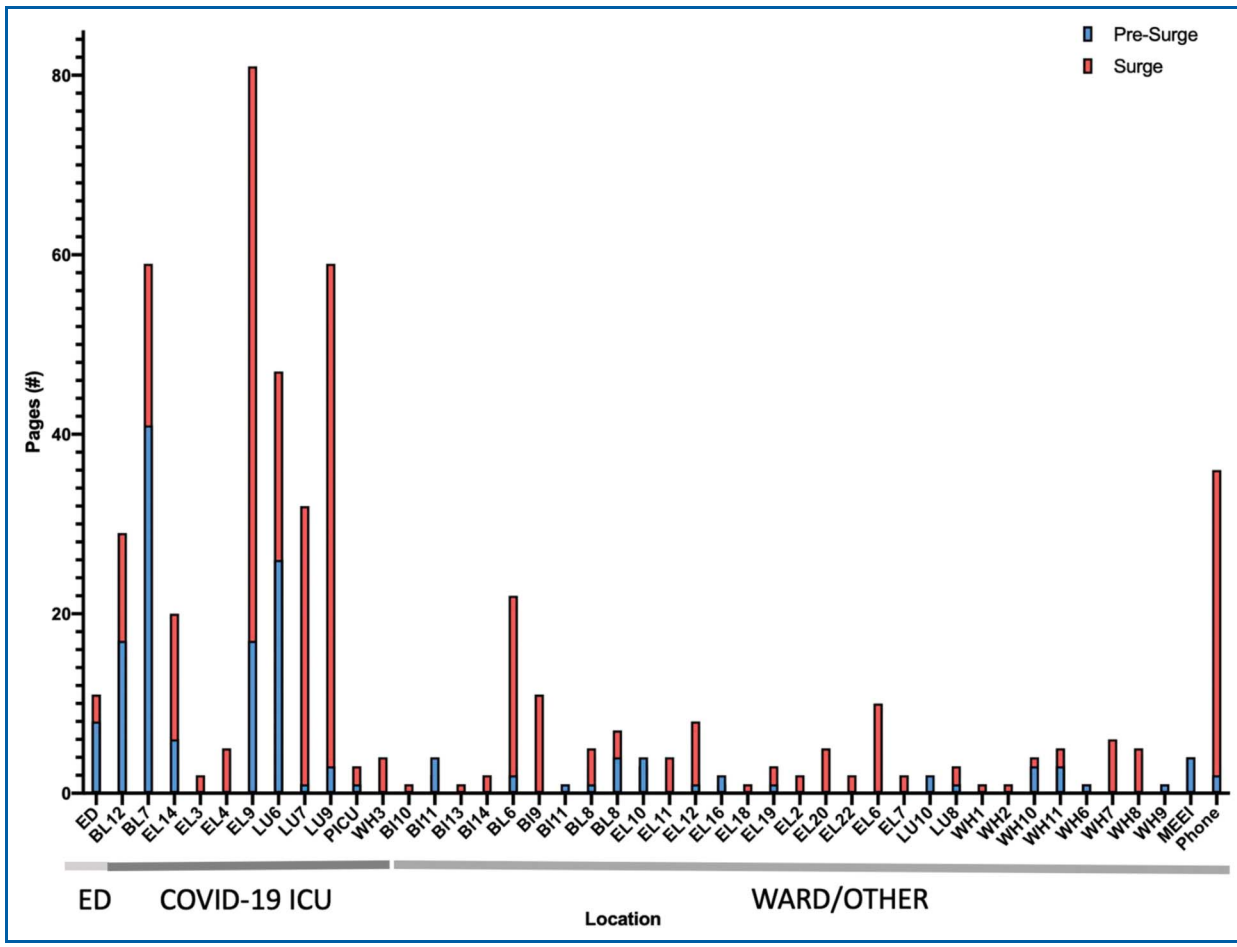

Figure 2. Locations of Airway Consults prior and during COVID-19 surge from March 10, 2020, to May 26, 2020. Overlay bar graph shows the number of pages before surge (blue) and during surge (red) with the various units in the hospital organized by either ED, COVID-19 ICU, or ward/others. ED, emergency department; ICU, intensive care unit.

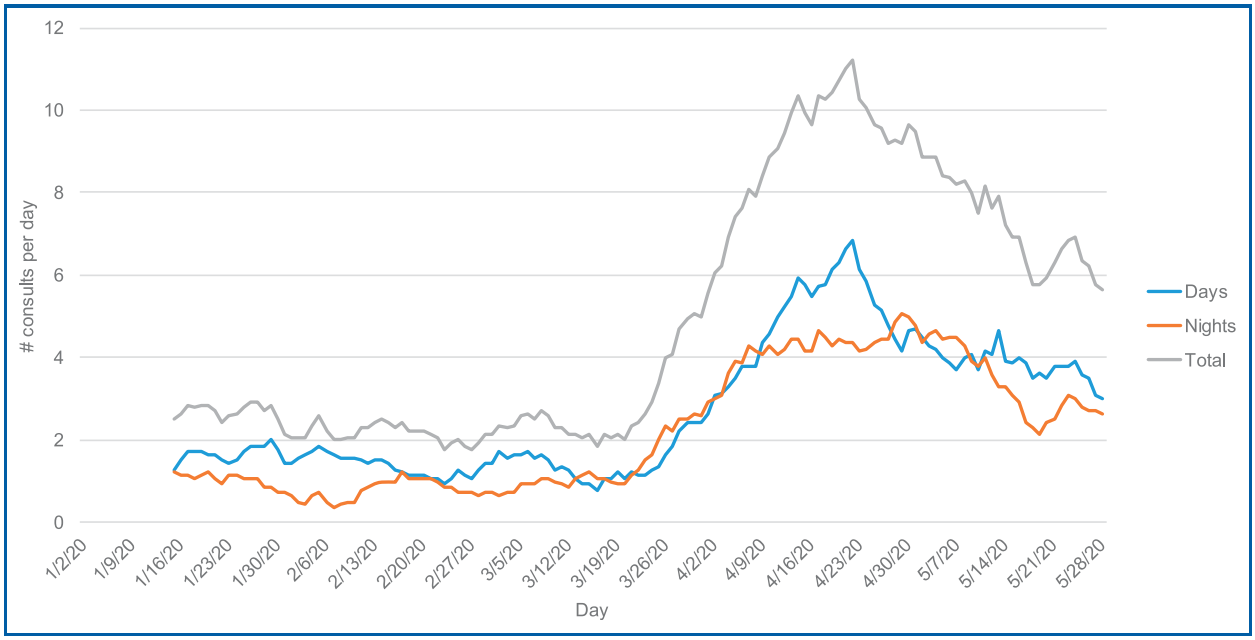

Figure 3. COVID airway response team consults by shift before and during the COVID-19 surge from March 10, 2020, to May 26, 2020.

airways, and no documented COVID-19 infections among CART providers. We found that performing data analytics using the CART paging system was an easy and rapid method to assess resource utilization, optimize staffing, and predict future demand during the COVID-19 surge and thereafter.

Emergency airway management is a vital resuscitative procedure that is associated with morbidity and mortality, especially when performed outside of the OR.[20,21] A growing body of literature details best practices for airway management of patients with COVID-19–associated respiratory failure requiring intubation.[4-6] However, this literature has primarily focused on the procedural aspects of airway management. The implementation of system-level solutions allowed our CART to manage the expected surge in patients requiring consultation for airway management while maintaining a high level of patient and healthcare worker safety. The design of our CART service during the COVID-19 pandemic borrows from both the airway and the quality improvement literature.[22,23] It uses an integrative approach that emphasizes operations, safety, and education to reinforce the central purpose of hospital-wide emergency airway management during the COVID-19 pandemic. Operations were standardized throughout the hospital and CART service, and CART consultation numbers and practice were reviewed daily by the CART team leader to allow for system-wide improvements. The combination of OR and ICU anesthesiologist was effective in facilitating safe emergency airway management through a team approach, minimizing trainee exposure and allowing intensivists to focus on leading ICUs.

In addition, monitoring emergency airway consult pages served as an efficient and effective method to track service demand during the surge and determine staffing needs for the CART as the number of hospitalized COVID-19 patients began to decline. Monitoring safety and quality of the CART practice was also facilitated by the use of CART consult pages. These data showed that indicators of quality and safety including intubation-related cardiac arrests and need for surgical airways did not increase during the surge. Furthermore, the frequencies of cardiac arrests and surgical airways are well below those reported in non-COVID series.[24,25] This is particularly notable given the substantial increase in the number of airway consults, increase in the number of intubations in non-ICU locations, increase in the number of overnight consults, and wider distribution of patient locations compared with the surge period. Although it is possible that preemptive intubation of COVID-19 patients with less severe illness may have contributed to these lower complication rates, it is reassuring given the increased demands resulting from the surge. The frequency of reintubations was found to

have increased during the surge, likely reflecting factors including accidental extubations during proning and extubation failure due to ICU-related weakness after prolonged mechanical ventilation. In addition, although increased from our baseline, the frequency of reintubation during the surge (13%) is consistent with the 10% reintubation frequency reported in the literature.[26] Because the CART was not routinely involved in extubation decisions, it is difficult to attribute this complication to the CART itself. Instead, it serves as a metric of demand for CART team utilization. Arguably, reintubation for respiratory failure is often more challenging than the initial intubation,[16] and despite the higher frequency of reintubation during the COVID-19 pandemic, there was not a significant increase in life-threatening complications which further highlights the beneficial impact of the system-level changes used by the CART. Finally, monitoring the health of providers participating in CART prospectively by the hospital protocol for all workers ensured that CART team members underwent regular screening, testing, quarantine, and care if needed. Retrospective evaluation by survey indicated that risk to CART team participants was well below the 3% of confirmed cases among healthcare workers involved in tracheal intubation of patients reported in a multinational study.[15]

Although rapid expansion of our preexisting airway service was effective in meeting the demands of the COVID surge within our institution, there are likely many alternative models that could and have been successfully used by other academic centers which account for differences in hospital size, staffing, and capacity surge demand. Institutions should be encouraged to report their experiences with system-based adaptations of emergency airway practice. In this way, strategies can be compared, best practices can be formulated, and guidelines can be developed for future recurrences of COVID-19 or other pandemic respiratory illnesses.

Conclusions

Success of CART resulted from a deliberate systems-level approach to expand a preexisting airway response service within a large academic medical center. Through a needs analysis that took into account both existing resources and anticipated demands, we determined priorities and solutions for the problems encountered during the pandemic. The result was a system-level solution that prioritized patient safety, provider protection, and close performance monitoring. Although hospitals vary in size and resources, we believe that such a system-level approach to design and implementation can be successfully used by other institutions challenged by the increased airway management demands resulting from the COVID 19 pandemic. Future studies should examine the comparative effectiveness of our CART service with practices of other institutions and evaluate how CART has impacted patient outcomes, operational efficiency, and costs of care.

Implications

The COVID-19 pandemic presents novel and unusual healthcare challenges, resulting from the ease of viral spread, the severity of the disease for many affected patients, and the substantial threat of infection for healthcare providers. Healthcare systems must rapidly adapt to respond to the increased healthcare demands while maintaining high-quality patient care and provider safety. This study adds to the literature detailing successful approaches to adapt to the surge of COVID-19 patients requiring airway management. The system-level approach to design and implementation described in this study can be used by healthcare systems as the current pandemic continues to unfold or for any future contagion that may cause a surge or overcrowding.

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