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Proning During Pandemic: The Rapid Institution of a Safe, Transferable, and Effective Prone Positioning Program at Nychhc/elmhurst Hospital, A Situationally Resource Limited Facility, During the Peak of the Covid 19 Surge

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Abstract

Introduction:

The use of prone positional therapy for moderate and severe hypoxicAcute Respiratory Distress Syndrome (ARDS) is known to decrease mortality. There are barriers to the routine use of Intermittent Prone Positioning (IPP), yet medical facilities are being overwhelmed with hypoxic patients due to COVID 19. We present the evolution of a high reliability protocolized program for IPP using minimal materials at the peak of the surge of COVID 19 patients that is applicable in settings of significant limitations and austerity.

Methods:

In the second week of April 2020 the program evolved through a series of short loop quality-based changes based in the principles of High Reliability Organizations (HROs) and Crew Resource Management (CRM). Patients with moderate to severe ARDS [PaO_2:FiO_2 ratio (PFr) was $\leq$ 150 on an $FiO_2 \geq 0.6$ and a PEEP $\geq$ 5 cm H_2O] were eligible to receive IPP.

The prone team consists of five to seven persons and patients were placed in the prone position for 16 hours and supine for 8 hours each day. When their PFr was $\geq$ 200 for > 8 hours supine, positional therapy ceased. Patients were positioned prone using only available materials without additional work from the bedside physicians, registered nurses (RNs) or respiratory therapists (RTs).

Arterial blood gases (ABGs) provided the measures of PaO_2, $PaCO_2$ and FiO_2 and enabled calculation of the PFr and the SaO_2:FiO_2 ratio (SaFr). Data were collected concurrently by prospective intention for quality assessment. Data are reported as number (n) and percent (%) or mean ± standard error of the mean (SEM) and range. Changes in $PaCO_2$, PF ratios, and SaF ratios are made by paired sample t-tests (2-tailed). Associations of PFr and SaFr at one hour pre-prone are evaluated using Pearson's correlation and simple linear regression. Data were evaluated using R® Version 1.2.1335 (R Foundation for Statistical Computing, Vienna Austria) and significance is noted at $\alpha < 0.05$ ($p < 0.05$).

Results:

Patients were treated between 14APR2020 and 09MAY2020. The peak of COVID 19 related deaths in New York was the 15th of April 2020. There have been 202 movements to the prone position and patients have received between 1 and 15 IPPs. There are 32 patients in the reported cohort and currently 12 patients are receiving IPP each day. Patients were 58.3± 1.7 years of age (37 to 73 years), 77% were male and had a BMI (body mass index) of 27.9 ± 0.7 (21 to 35). Pressor agents were being used in 74%, 16% were receiving dialysis, the white blood cell counts were 17.0 ± 1.5 (10^3/mcL) and their D dimers were 4630.0 ± 1588.0 ng/mL. At the time of consultation for prone positional therapy the patient's arterial blood gas analyses were pH 7.28 ± 0.02, $PaCO_2$ 63.1 ± 3.53 mmHg, PaO_2 of 80.5 ± 5.3 mmHg, HCO_3 of 27.8 ± 1.0 mmol/L.

The PFr prior to IPP was 108.0 ± 5.4and 1 hour after IPP was 152.8 ± 11.2 ($p < 0.001$). PFr after the patients were placed supine was 128.8 ± 9.2 ($p = 0.014$). Pre-prone $PaCO_2$ was 59.7 ± 2.4 and the 1-hour post-prone $PaCO_2$ was 68.9 ± 3.5 ($p = 0.017$ compared to pre-prone). The $PaCO_2$measured supine one hour after IPP was 60.7 ± 3.3 (NS compared to pre-prone).The SaFr prior to IPP was 121.3 ± 4.2 and the SaFr 1 hour after positioning was 131.5 ± 5.1 ($p = 0.012$). The SaFr after the patients were placed supine was 139.7 ± 5.9 ($p < 0.001$ compared to pre-prone).Using regression coefficients, the SaF ratios predicted by PF ratios of 150 and 200 are 133.2 and 147.3, respectively.

Conclusions:

A program for prone positioning of adult patients with severe hypoxic ARDS due to COVID 19 can be designed and implemented rapidly, safely, and effectively during an overwhelming mass casualty scenario. This report describes one simple method that does not require any additional materials or labor from the already overburdened staff at the bedside. This approach may be equally applicable in both traditionally austere environments and in otherwise capable centers facing situational resource challenges.

Introduction

The use of prone positional therapy for severe hypoxic Acute Respiratory Distress Syndrome (ARDS) is known to decrease mortality by approximately one half[1,2]. Although there are atypical aspects to the hypoxemic lung failure caused by COVID 19 (Corona Virus Disease 2019, SARS CoA – 2), these patients respond to positional therapy much like other patients with severe hypoxemic ARDS [PaO_2:FiO_2 ratio (PFr) < 100].

There have been many barriers to the routine use of Intermittent Prone Positioning (IPP) for patients with ARDS and yet, throughout the world, medical facilities are being overwhelmed with hypoxic patients due to COVID 19. Our goal was to institute a positional therapy program during a period of extreme institutional stress and to adapt the procedure to be applicable in settings of significant limitations and austerity.

We present the evolution of a high reliability protocolized program for prone positioning using minimal materials in NYCHHC/Elmhurst Hospital in New York City during early April 2020 at the peak of the overwhelming surge of COVID 19 patients. This work was conceived and implemented with a focus on small team dynamics and performance improvement based in the principles of High Reliability Organizations[3] (HROs) and Crew Resource Management[4] (CRM).

These methods may be applicable in other centers that recognize the need for safe, effective positional therapy but have not developed a means of doing so. This is a proof of concept manuscript of a rapid, quality-based method for the implementation of prone positioning in a chronically or acutely resource limited and challenged environment.

Methods

In the second week of April 2020 this project was conceived, designed, and implemented. The development of the program evolved through a series of many short loop quality-based changes made and evaluated in real time. These norms of immediate debriefing and concurrent data collection, evaluation and utilization for both process and clinical decision making utilized the principles of HROs and CRM and guided the program. We encouraged a flattened hierarchy and non-punitive feedback with a focus on the traits of HROs. These principles enabled the team to operationalize the primary goals with the speed and safety required under the conditions at NYCHHC/Elmhurst during early April 2020.

The prone team consists of five to seven persons, four to six to roll the patient and one to control the airway. The airway is managed by either an intensivist or a Certified Registered Nurse Anesthetist (CRNA) deployed by the military and four to six military medics. Two teams work 12-hour shifts each. The initial training of these teams consisted of short lectures and a three-hour hands-on simulation. Subsequent medics and non-medical team members received training at the bedside. Intensivists attended each positional change to assure compliance with the process, facilitate rapid debriefings, institute quality adjustments, and manage critical physiologic changes in the patient. In a mature form, the team will consist of a respiratory therapist (RT) for the head and bedside nurses (RNs) for the roll. Nonmedical personnel can also fill these roles but will be less capable of responding to emergencies.

Patients were enrolled in the protocol if their PaO_2:FiO_2 ratio (PFr) was ≤ 150 on an $FiO_2 \geq 0.6$ and a positive end expiratory pressure (PEEP) ≥ 5 cm H_2O provided they were between 18 and 75 years of age and had been mechanically ventilated for ≤ 14 days. Patients were excluded only if they were minors or > 75, if their time on the ventilator was > 14 days, they had unmanaged abdominal compartment syndrome or had had pacemaker insertion within the prior 48 hours. These decisions for exclusion were primarily due to the volume of patients presenting with severe hypoxia.

Consultation to the prone team was made at the discretion of the primary treatment teams. Patients were placed in the prone position for 16 hours and supine for 8 hours each day as described in the Proning Severe ARDS Patients (PROSEVA) trial. When their PFr was ≥ 200 for > 8 hours supine, their positional therapy ceased. This protocol was designed specifically for ventilated patients. Non-ventilated patients were treated under different positional care approaches and are not reported here.

Patients were positioned prone using three pillows, four sheets, and a blanket. When pillows were not available, a folded blanket was used. When blankets were not available, several sheets were substituted. The purpose of the pillows (or other materials) is to lift the chest and pelvis to allow the abdomen to hang free without pressure and to stabilize the anterior chest wall. Current ventilator settings were maintained except for an increase to an FiO_2 of 100% for ten minutes for preoxygenation before each positional change. The endotracheal tubes (ETTs) were secured with an Anchorfast Oral Endotracheal Tube Fastener® (Hollister, Libertyville IL) and maintained in the midline.

A team of five to seven persons, two or three on each side of the patient and one for the airway, conducted the position changes without additional work from the bedside physicians, RNs, or RTs. The patient's head and arms were repositioned in the "swimmer's position" and changed from side to side by three members of the prone team every 4 hours while prone. Further details of the protocol and procedure, including checklists, are listed in appendices A, B and C.

Due to the resource scarcity the patients were supported by several types of ventilators including the Puritan Bennet 840® (Medtronic, Minneapolis MN), the Dräger Evita V500® (Draeger Inc. Telford PA), the Maquet Servo-i® (Getinge LLC, Wayne NJ), the Respironics V60®, the Phillips EVO Trilogy (both Koninklijke Philips N.V.), and the LTV 1000® (Vyaire, Mettawa IL). Standard principles of protective ventilation strategies including the limitation of peak airway pressures to < 30 cm H_2O and tidal volumes of 6–8 cc/kg guided therapy. Moderate hypercapnia was tolerated provided the pH was > 7.20.

Arterial blood gases were measured at four time points; one hour prior to the first movement from supine to prone, one hour after the patients were placed prone, one hour prior to being returned to the supine position (prone hour 15) and one hour after being placed supine. These ABGs provided the measures of PaO_2, $PaCO_2$ and FiO_2 and enabled calculation of the PaO_2:FiO_2 ratio (PFr) and the SaO_2:FiO_2 ratio (SaFr).

Data were collected concurrently by prospective design to inform and evolve the quality of the project. In addition to patient related data, every maneuver was followed by a debriefing during which quality issues identified were addressed in a short loop cycle. Data are reported as number total (n) and percent (%) or mean ± standard error of the mean (SEM) and range. Changes in $PaCO_2$, PF ratios, and SaF ratios between proning stages are made by paired sample t-tests (2-tailed). Associations of PFr and SaFr at one hour pre-prone are evaluated using Pearson's correlation and simple linear regression. Data were evaluated using R® Version 1.2.1335 (R Foundation for Statistical Computing, Vienna Austria). Demographic characteristics are reported for the full cohort (n = 31) and cases with missing data were excluded case-wise for analysis requiring those data points. Significance is noted at $\alpha < 0.05$ ($p < 0.05$). As a Quality Improvement process, this project has been granted an exception from review by the Institutional Review Board of NYCHHC/Elmhurst Hospital Center.

Results

At the time of reporting, 40 patients were referred, and 32 patients have been treated with prone positioning. Patients were excluded for duration of ventilation > 14 days, BMI > 35, and demand beyond capacity (15 patients/day). The patients were treated between 14APR2020 and 09MAY2020. The peak of COVID 19 related deaths in New York was the 15th of April 2020. At the time of this report there have been 202 movements to the prone position and an equal number to the supine position. Individual patients have received between 1 and 15 IPPs. Currently there are 12 patients receiving positional therapy each day.

Sample characteristics are presented in Table 1. The patients were 58.3 ± 1.7 years of age (range 37 to 73 years) and 77% were male and had a BMI of 27.9 ± 0.7 (range 21 to 35). Pressor agents were being used in 74%, 16% were receiving dialysis, the white blood cell counts were 17.0 ± 1.5 (10^3/mcL) and their D dimers were 4630.0 ± 1588.0 ng/mL.

Table 1
Case Characteristics at baseline (n = 31)

Age (years)	
Mean (SEM)	58.3 (1.7)
Range	37.0 to 73.0
Sex (n (%))	
Female	7 (22.6)
Male	24 (77.4)
BMI	
Mean (SEM)	27.9 (3.8)
Range	21.0 to 35.0
White blood cell count (10^3/mcL)	
Mean (SEM)	17.0 (1.6)
Range	5.7 to 48.4
D dimers (ng/mL)	
Mean (SD)	4630 (1680.8)
Median [Min, Max]	386 to 47500
Creatine (mg/dL)	
Mean (SEM)	1.5 (0.2)
Range	0.3 to 4.9
Dialysis (n (%))	
No	25 (80.6)
Yes	5 (16.1)
Pressor (n (%))	
No	7 (22.6)
Yes	23 (74.2)

The basic ventilator settings at the time of consultation were an FiO_2 of 0.81 ± 0.14 (range 0.5 to 1.0), a PEEP of 10.1 ± 0.6 (range 5 to 18 cm H_2O) with modes including Airway Pressure Release Ventilation (APRV), Pressure Control Ventilation (ACPC), and volume control (ACVC). At the time of consultation for prone positional therapy the patient's arterial blood gas analyses were pH 7.28 ± 0.02, $PaCO_2$ 63.1 ± 3.53 mmHg, PaO_2 of 80.5 ± 5.3 mmHg, HCO_3 of 27.8 ± 1.0 mmol/L.

Table 2 displays the respiratory characteristics (PF ratio, $PaCO_2$ and SaF ratio) of patients at each proning stage (pre-prone, 1 hour post-prone, 15 hours post-prone, and 1-hour post-supine). It is apparent that oxygenation increased with prone positioning and a more modest but significant increase of the PFr persisted after return to the supine position. In addition, there was an increase in the $PaCO_2$ throughout the time in the prone position but a return to baseline in the supine position following prone therapy. The SaF ratio demonstrates a similar pattern with oxygenation improving throughout the time in the prone position and an enduring effect when returned supine.

Table 2
Respiratory Characteristics of COVID 19 patients treated with Prone Positioning

Position and Variable	Mean ± SEM	Range	Paired-sample t-test (2-tailed)
PF ratio (n = 30)			
Pre-prone	108.0 ± 5.4	64.0 to 179	NA
1 hr prone	152.8 ± 11.2	69.5 to 295	[a] $t = 4.13$, $p < 0.001$
15 hr prone	139.1 ± 10.8	53.8 to 290	[a] $t = 3.10$, $p = 0.004$, [b] $t = -1.14$, $p = 0.263$
1 hr post-supine	128.8 ± 9.2	50.6 to 233	[a] $t = 2.61$, $p = 0.014$, [c] $t = 1.05$, $p = 0.301$
$PaCO_2$ (n = 30)			
Pre-prone	59.7 ± 2.4	39.5 to 87.0	NA
1 hr prone	68.9 ± 3.5	41.3 to 120.0	[a] $t = 2.54$, $p = 0.017$
15 hr prone	65.9 ± 3.0	37.0 to 100.0	[a] $t = 2.04$, $p = 0.050$, [b] $t = -0.91$, $p = 0.368$
1 hr post-supine	60.7 ± 3.3	33.1 to 124.0	[a] $t = 0.38$, $p = 0.707$, [c] $t = -1.67$, $p = 0.106$
SaF ratio (n = 29)			
Pre-prone	121.3 ± 4.2	90.0 to 181.6	NA
1 hr prone	131.5 ± 5.1	86.3 to 197.2	[a] $t = 2.69$, $p = 0.012$
15 hr prone	139.9 ± 5.1	86.3 to 197.4	[a] $t = 3.90$, $p < 0.001$, [b] $t = 1.84$, $p = 0.080$
1 hr post-supine	139.7 ± 5.9	92.0 to 233.5	[a] $t = 3.55$, $p < 0.001$, [c] $t = 0.091$, $p = 0.928$
[a] Change from pre-prone			
[b] Change from 1 hr prone			
[c] Change from 15 hr prone			

The PFr prior to the initial prone positioning was 108.0 ± 5.4 and the first PFr in the prone position, measured 1 hour after positioning was 152.8 ± 11.2 ($p < 0.001$ compared to pre-prone). The PFr after 15 hours prone was 139.1 ± 10.8 ($p = 0.004$ compared to pre-prone, NS compared to 1 hr post-prone) and the

PFr after the patients were placed supine was 128.8 ± 9.2 ($p = 0.014$ compared to pre-prone, NS compared to 15 hours post-prone).

Ventilation was affected by prone positioning with mild worsening of the hypercapnia. The pre-prone $PaCO_2$ was 59.7 ± 2.4 and the 1-hour post-prone $PaCO_2$ was 68.9 ± 3.5 ($p = 0.017$ compared to pre-prone). The $PaCO_2$ after 15 hours prone was 65.9 ± 3.0 ($p = 0.05$ compared to pre-prone, and NS compared to one hour post-prone) and the first supine $PaCO_2$ measured one hour after prone positioning was 60.7 ± 3.3 (NS compared to pre-prone, NS compared to 15 hours post-prone).

The SaFr prior to the initial prone positioning was 121.3 ± 4.2 and the first SaFr in the prone position, measured 1 hour after positioning was 131.5 ± 5.1 ($p = 0.012$ compared to pre-prone). The SaFr after 15 hours prone was 139.9 ± 5.1 ($p < 0.001$ compared to pre-prone, NS compared to 1 hr post-prone) and the SaFr after the patients were placed supine was 139.7 ± 5.9 ($p < 0.001$ compared to pre-prone, NS compared to 15 hours post-prone).

The correlation of SaF ratio with the PF ratio yields an $r = 0.374$. A simple linear regression was fit to predict SaF ratio based on PF ratio using data from patients in the pre-prone position. The model R^2 was 0.108 (F-statistic = 4.38, $p = 0.05$) with a β_0 intercept of 91.0 ($p < 0.001$) and a β_1 slope of 2.8 ($p = 0.046$). Using these regression coefficients, the SaF ratios predicted by PF ratios of 150 and 200 are 133.2 and 147.3, respectively.

Complications included pressure ulcers in six patients; four on the anterior torso, one related to a mal-positioned nasogastric tube on the upper lip and two with wounds to the cheeks from the tube holder. In these two patients the tube holder was simply inverted, seated on the lower lip and the wounds were treated in a standard fashion. All were stage I or II wounds. There were two episodes of tongue edema, one of which involved hemorrhage. Both were managed by reduction of the edematous tongue to the oropharynx and resolved in the supine position. Neither compromised further positional care. There have been no inadvertent extubations or disruptions of arterial lines, central venous catheters, chest tubes or dialysis catheters.

There were seven unscheduled returns to the supine position. These were due to a mucous plug in the endotracheal tube, a cardiac arrythmia, CO_2 retention to 138 mmHg and acute hypotension. Only two were evaluated as necessary in a short loop quality review. One unplanned return to supine was due to sudden cardiac arrest not due to the positional therapy or tension pneumothorax.

Discussion

We report the process of implementing a safe, effective way to prone hypoxic patients with minimal materials and without disrupting a system already overwhelmed in a disaster scenario. This is not intended to be an outcome assessment but rather a process evaluation and description of one safe, effective protocol for positional care developed and implemented in a stress induced limited resource setting.

The value of prone positioning in severe ARDS has been supported with class I data since the post hoc analysis of the Prone-Supine group in 2001[1] but was not widely accepted until the PROSEVA trial reported in 2013[2]. We have had experience with positional therapy for ARDS over many years and in many clinical scenarios[5] but at the time of the COVID 19 surge in New York City there was no experience with routine positional care for ARDS in the NYCHHC/Elmhurst Hospital.

NYCHHC/Elmhurst Hospital Center has been described as the “epicenter of the epicenter”[6] at the time of the peak in deaths in New York State. At that time, the number of ventilated adult patients in the institution had increased from approximately 30 per day to a maximum of 167 in three weeks’ time. In addition, many staff members became ill, newly improvised critical care units were opened and staff were tasked with an increased level of disease acuity and responsibility, all of which severely stressed the medical system. There were unprecedented shortages of RNs, critical care physicians, RTs, critical care units and ICU beds, laboratory capacity, imaging capacity, medications, CPAP equipment, ventilators, vascular access and dialysis catheters and virtually everything else required for the care of patients with severe lung failure.

Our goal was to provide prone positional therapy in an institution that had never operationalized that aspect of pulmonary critical care before. To do so, especially in a time of volume crisis and situational resource limitation, we sought to proceed with several core principles:

1) The positional therapy must be both safe and demonstrably effective.

2) The process must not require any additional work of the physicians, RNs and RTs involved in the care of the patient.

3) Only readily available materials would be used.

4) Our inclusion criteria and clinical processes would reflect the methods of the Class I data produced from the PROSEVA trial.

5) The program would adhere to principles of HROs.

6) Rigorous adherence to check lists improved continually and in real time and CRM principles would guide all activities from training to practice to evaluations.

7) Intense attention to error in a short loop quality cycle would inform and guide rapid changes and this would be a norm of the team.

8) Concurrent data collection including opportunities for improvement identified in routine post procedure debriefing would inform quality decisions and facilitate protocol transfer.

9) These protocols would be easily adopted by the bedside nurses (RNs) and respiratory therapists (RTs) when the number of critically ill patients returned to a more manageable volume.

Basic principles of HROs and CRM guided the evolution of the program and the culture. These principles enabled the team to implement the primary goals with the speed and safety required under the conditions at NYCHHC/Elmhurst during early April 2020. We purposefully designed and led the evolution of the program with a focus on the five traits of HROs: sensitivity to operations, reluctance to oversimplify the reasons for problems, preoccupation with failure, deference to expertise and resilience.

Specifically, these principles informed our decisions as follows. Sensitivity to operations was evident in the realization that we were functioning in an institution with a high volume of COVID patients with severe ARDS and overwhelmed bedside RNs, RTs, and critical care physicians. The resource limitations in many areas at that time approached those of an austere environment. Reluctance to accept “simple” explanations for problems was a primary motivation for rapid time and point of service debriefings, many short loop correction and re-evaluation cycles and a focus of root causes in the systems domain of error. A preoccupation with failure was best exemplified with a team ethos of an a priori stated concern with “what could possibly go wrong” and a purposefully maintained non punitive flat hierarchy to facilitate criticisms. We also normalized the use of multiple checklists and the simple use of the word “STOP” at any point by any team member. We deferred to expertise whenever possible recognizing that one program leader brought local cultural, academic, clinical pulmonary/medical perspectives, political strength and legitimacy and longevity to the process and the other provided experiential strength with IPP, clinical surgical/ECMO perspectives, program development and performance improvement insights and small team leadership skills. The meticulous attention to detail, discipline, and protocol/de-briefing familiarity of the deployed military team members was an additional asset. Finally, this program was developed and evolved in a dynamic and dangerous environment. Many compromises and great flexibility defined both the scenario and the cultural norms of the team. Resiliency is defined as the “ability to recover from or adjust easily to adversity or change[7]” and that characteristic is a defining principle of the team. In addition, change was expected and encouraged in rapid sequential quality loops.

The prone team is a cohesive and independent operational team, traits that made it possible to develop rapidly utilizing the principles of CRM. These principles provide a framework for the type of high reliability activity that prone and supine positioning of severely ill and vulnerable patients in a hostile environment characterized by many systems deviations and significant infectious risk to the providers demands. The core principles of CRM that were applicable to this project include a flattened hierarchy, individual and team situational awareness, focus on systems and human errors, non-punitive and immediate feedback, structured communication, crosscheck techniques, and maintaining team integrity and safety.

Our data collection is designed only to assure quality of the intervention and to show that in this setting IPP improves oxygenation as it does with other types of ARDS. In addition, this protocol is applicable in settings where ABGs may not be available by utilizing the pulse oximeter to assess oxygenation. These relationships have been well shown in other populations and they continue to apply under these conditions.

This brief report has several limitations. First, our goal was to produce a process report as quickly as was responsible and valid to assist other medical centers in providing positional therapy for the first time despite situationally limited resources. This project was neither designed nor intended to produce outcome data. Many of the patients were still extremely ill and receiving ongoing care, including prone positioning, at the time we chose to report the series. Second, because we only intended to validate the safety and effectiveness of the process, and to produce a rapid report, we chose to report a case series that was small. Third, our measure of the saturation to inspired oxygen (SaF ratio) utilized the measured SaO_2 instead of the observed peripheral pulse oximeter saturation (SpO_2). It is a surrogate for an index of oxygenation using only the pulse oximeter (SpF ratio) applicable to more austere settings but, again due to the sheer volume of patients, we were unable to collect those readings with validity. Fourth, our correlation of SaFr with PFr and model fit were only moderately strong and should therefore be interpreted with caution. Moreover, prediction of SaFr based on PFr may not be generalizable to other populations except in concept. Fifth, because we were introducing a seemingly dramatic intervention in an institution that was not familiar with it and that was experiencing multiple extreme stressors, we chose a posture of relative risk aversion regarding patient selection. The one risk we did accept was to position these patients prone with their Hollister ETT holders in place and the ETT in the midline. Under normal conditions this is not advised but we felt that it was necessary. It is preferable to tape the tube and reposition it as indicated and to preform early tracheostomy. At the height of the surge, due to multiple shortages and a temporary moratorium on tracheostomy, which is an aerosol generating procedure, positioning with the tube holder was the only option. With attention to detail in this regard we have not experienced more problems with the prone cohort than in the general intubated population related to that decision. Finally, our selection was limited by our belief that even a focused prone positioning team cannot safely manage more than 15 patients with their 30 positional changes and 45 head turns a day.

Patient safety is a critical endpoint of any medical process and the principles of HROs and CRM are good frameworks to assure the performance of teams in complex and dangerous environments. This is an environment of chaos and hazard characterized by overwhelmed systems, stressed and variously experienced personnel and an infectious agent that is transmitted by aerosol and respiratory droplets from asymptomatic carriers, has no treatment or vaccine and that has a significant infectivity and mortality. Team safety assumes greater dimensions in a truly hazardous environment. Teams, as well as systems, can suffer trauma just like an individual. Effectiveness and excellence in such a time depends on a culture with an unusual focus on safety with a holistic scope. Initiating a program of positional care in the COVID intensive care units (ICUs) at NYCHHC/Elmhurst required meticulous attention to these principles and, although each new situation will require modifications for local conditions, is transferable to other institutions facing similar challenges.

Although COVID 19 causes a type of severe hypoxemic ARDS that responds to positional therapy like other types of lung failure it remains to be seen if patient important outcomes like mortality can be affected. Those conclusions will require a study design and outcomes data not possible with this report's intentions and time frame. The data reported simply reflect that positional therapy in this scenario increases oxygenation, only modestly and transiently compromises ventilation, can be conducted with readily available materials, including only pulse oximetry, and an acceptable incidence of known complications.

Conclusions

A program for prone positioning of adult patients with severe hypoxic ARDS due to COVID 19 can be designed and implemented rapidly, safely, and effectively during an overwhelming mass casualty scenario. This report describes one simple method that does not require any additional materials or labor from the already overburdened staff at the bedside. This approach may be equally applicable in both traditionally austere environments and in otherwise capable centers facing situational resource challenges.

Abbreviations

ARDS Acute Respiratory Distress Syndrome

IPP Intermittent Prone Positioning

COVID-19 Corona Virus Disease 2019

SARS-CoV-2 Severe Acute Respiratory Syndrome Coronavirus 2

HRO High Reliability Organization

CRM Crew Resource Management

ABG arterial blood gas

PFr PaO_2 to FiO_2 ratio

RN registered nurse

RT respiratory therapist

SaFr SaO_2:FiO_2 ratio

n number % or mean ±

% percent

SEM standard error of the mean

BMI body mass index

CRNA Certified Registered Nurse Anesthetist

PEEP positive end expiratory pressure

PROSEVA Proning Severe ARDS Patients

ETT endotracheal tube

ICU intensive care unit

Declarations

Ethics approval and consent to participate

This is a Quality Improvement project and is exempted from IRB review. Likewise, as a protocol based in Class I data, individual consent was not required.

Consent for publication

The authors give consent for publication.

Availability of data and materials

The data used in the manuscript are available for review.

Competing interests

We report no disclosures related to competing interests.

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Authors' contributions

Program design AA and AM

Manuscript preparation AA, EM, and AM

Statistical analysis EM and AM

Manuscript revisions AA, EM, and AM

Data accountability AA, EM, and AM

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