TITLE: Prone Positioning of Patients With Acute Respiratory Distress Syndrome Related to COVID-19: A Rehabilitation-Based Prone Team

RUNNING HEAD: Prone Positioning in COVID-19–Related ARDS

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Objective. Prone positioning is an effective intervention for acute respiratory distress syndrome (ARDS). An increasing number of patients with ARDS related to coronavirus disease 2019 (COVID-19) required prone positioning, which posed a challenge to the intensive care unit (ICU) staff at Brigham and Women's Hospital.

Methods (Case Description). A prone team service of physical therapists and occupational therapists with critical care experience was established to assist with increasing demands for prone positioning of patients who were mechanically ventilated. The goals of the rehabilitation-based prone team were to provide support to nursing and respiratory therapy; create a consistent, efficient process; and ensure patient and staff safety.

Results. The service evolved over 7 weeks, expanding to 24-hour coverage and adding responsibilities to support the staff as patient volume grew. Volume of requests to the rehabilitation-based prone team generally increased to week 4 and has since then declined. Key points for successful implementation included identification of rehabilitation therapists with ICU experience and leadership qualities, multidisciplinary collaboration, availability of needed positioning devices and supplies to protect the integument, and well-defined roles of all disciplines participating in position change process.

Conclusion. The description of the development, operations, evolution, and utilization of a rehabilitation therapist prone team acts as a guide for future development and implementation.

Impact. This case report is one of the first reports of a rehabilitation-based prone team established to assist with positioning patients in prone as an intervention for ARDS related to COVID-19 and will help guide other institutions.

The novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was first reported in Wuhan, China, in December 2019 and causes an acute respiratory illness named coronavirus disease 2019 (COVID-19).[1] Initial data from the United States reported that 20 to 31 percent of patients with COVID-19 develop respiratory symptoms requiring hospitalization and 4.9 to 11.5 percent of patients require admission to the intensive care unit (ICU).[2] Patients with COVID-19 can develop hypoxemic respiratory failure, and chest imaging has shown ground-glass opacities that progress to a mixed presentation with consolidation primarily in the bases of the bilateral lungs.[3] Coronavirus Disease 2019 can be complicated by acute respiratory distress syndrome (ARDS), a condition that results in hypoxemia and acute lung injury.[1,4] As COVID-19 progressed to a pandemic, hospital clinicians worldwide collaborated to establish guidelines for management of patients with COVID-19 and ARDS.[5]

Prone positioning was successfully implemented as a treatment for ARDS in 1976.[6] Effects of prone positioning include homogenous lung pressures, uniform alveolar size, and improved ventilation of the posterior lung fields.[7] Perfusion is improved due to decreased intrapulmonary shunting.[5,7] These factors improve oxygenation and reduce overall mortality associated with ARDS.[8,9] Therefore, prone positioning is recommended as a treatment for patients with moderate to severe ARDS from COVID-19.[5]

The first presumed case of COVID-19 in Massachusetts was documented on March 2, 2020.[10] Within one week, the number of cases increased to 40 presumed and one confirmed by the United States Centers for Disease Control and Prevention.[11] An additional week of testing resulted in 197 presumed cases in Massachusetts.[11] As the number of patients with COVID-19–

related ARDS increased at our institution, teams consisting of one respiratory therapist and typically four ICU nurses began to position patients who were mechanically ventilated into prone. Positioning patients into prone is a complex task that carries risks including displacement of endotracheal tubes and other vital lines during the procedure, hemodynamic instability, corneal abrasions, nerve injury and skin breakdown with prolonged time in prone.[5] Managing the escalating number of patients requiring prone positioning became challenging for ICU staff. Rehabilitation therapists with ICU experience have unique training and expertise for positioning patients into prone during the COVID-19 pandemic.[12]

This article is a description of the establishment, operation and evolution of a rehabilitation therapist staffed prone team. The prone team assisted nursing and respiratory therapy to complete the task of positioning patients who were mechanically ventilated into prone over several weeks. The experience, progression and preliminary data may inform and guide future work.

[H1] Case Description

The prone team service was created when leadership of the rehabilitation department at Brigham and Women's Hospital, a large academic medical center, in collaboration with the nursing department identified the need for assistance with prone positioning of patients with COVID-19–related ARDS. Rehabilitation therapists did not assist with positioning patients into prone prior to the COVID-19 pandemic. The prone team service was made up of physical therapists and occupational therapists from the rehabilitation department with experience in the ICU. Three members of the prone team service covered each shift and were defined as the prone team. The role of the prone team was to assist nursing and respiratory therapy with position changes and positioning in prone. Positioning changes included prone to supine, supine to prone,

repositioning of the head and neck of patients in prone and turns of patients in the supine position. As requests for assistance increased, a support prone team of 2 additional rehabilitation therapists was created to assist the prone team with position changes. The goals of creating a prone team service were to provide support to nursing and respiratory staff with increasing patient care demands, to establish consistency and efficiency during the prone positioning process and to ensure the safety of patients and staff.

The prone team service members were identified by rehabilitation leadership based on their ICU experience, leadership qualities, flexibility, clinical knowledge and judgment. Training methods were developed and implemented within one week (Fig. 1). Training was based on our institutional nursing policy for prone positioning for ARDS. Prone team service members reviewed relevant literature describing prone positioning for ARDS[7] and the process of prone positioning.[9,13] Hands on training occurred with guidance from experienced medical ICU nurses and rehabilitation leadership.

The prone team operated per the medical orders of the ICU physicians. Decisions on when to position a patient who was mechanically ventilated in prone, length of time spent in prone and medical tolerance of the prone position were the responsibility of the physicians based on guiding criteria (Tab. 1). Literature describing prone positioning recommends 5-6 staff present for the prone positioning process.[13] Position changes from prone to supine and supine to prone were performed with a multidisciplinary team consisting of at least one nurse, one respiratory therapist and the prone team. All three disciplines functioned within their scope of practice and per physician orders.

The prone team was contacted by the physician or nurse when the need for patients to be placed in the prone position was identified. A dedicated pager was established for direct contact with the prone team. A scheduled time was determined based on the availability of the nurse, respiratory therapist and the prone team. A thirty to sixty-minute notice was encouraged for coordination of medications, cessation of tube feeding and gathering supplies. Collaboration during the process of prone positioning occurred between all three disciplines with the prone team providing the physical expertise (Tab. 2), nursing providing necessary medication and line management and respiratory therapy providing airway and ventilator management (Fig. 1). Positioning devices were chosen and utilized based on the patient's body habitus[13] (Tab. 2). Varying individual patient factors required modifications to achieve desired positioning and alignment (Tab. 2). For patients with complex wound care needs, a wound care nursing consult was recommended.

Each prone team provided verbal handoffs to the oncoming prone team shift. A tracking document was created to communicate amongst prone team members between shifts. The document included time of communication with physician or nurse, position change to be performed, number of prone team members involved, additional staff needed and problem-solving strategies. Updated operations were communicated via email from rehabilitation leadership to prone team service members, nursing managers and the respiratory therapy department.

[H1] Outcomes

The first patient with COVID-19 was admitted to our institution on March 14, 2020. The first time that the rehabilitation-based prone team assisted with positioning a patient with COVID-19–

related ARDS into prone was on April 3, 2020. Subsequently, the prone team service was established for assistance during a 10-hour day shift, 7 days per week on April 6, 2020. As the volume of patients requiring prone positioning increased, the prone team service availability expanded to 24 hours, 7 days per week on April 12, 2020. The support prone team was available during 10-hour day shifts starting April 19, 2020 (Fig. 1). The number of COVID-19 cases in our institution peaked during the weeks of April 19, 2020 and April 26, 2020 and have since declined.

Throughout 7 weeks, the total volume of requests to the prone team for position changes was 934. The volume generally increased until week 4, and then progressively decreased (Tab. 3, Fig. 3). The specific position change volume included 253 prone positioning, 235 supine positioning, 280 repositioning of the head and arm in prone, 72 turns (weight shifting in any position), 88 cancelled events (reasons not recorded), 4 prone positioning with immediate return to supine (reasons not recorded) and 2 requests with missing event details. The day shift prone team received 64% of the request volume while the night shift received 36% of the request volume.

Of the 934 documented requests to the prone team, there were 838 position change events with the number of prone team members recorded. Of the 838 events, 70% involved 3 prone team members, 26% involved 2 prone team members, 13% involved only 1 prone team member and 11% involved 4 prone team members (additional members supplemented by support prone team). Reasons for variable prone team members were not recorded. Additional medical staff were present at times, such as physicians, nursing extenders or respiratory therapists. The need

for additional staff was variable and dependent on the patient's medical condition and body habitus. Reasons for increased number of staff were not recorded.

The amount of time for each position change was recorded in 821 position change events by the prone team. The amount of time that the prone team spent during each position change event (time in the patient room) varied. The mean (SD) number of minutes was 20 (9.15) with a range of 5 to 80 minutes. Reasons for time variations were not recorded.

The prone team recorded preliminary information regarding process operations for scheduling and positioning purposes. The prone team did not record adverse events that may have occurred during mobility or intolerance criteria per the physicians. The prone team did not enter patients' electronic medical records, record any patient information or follow any outcome data.

[H1] Discussion

As planning for the COVID-19 pandemic began, hospital leadership took steps to prepare for the anticipated surge of patients. Hospital and rehabilitation censuses were reduced, and staff were redeployed to new roles within the hospital. Rehabilitation therapists were utilized in the development and implementation of a prone team to assist nursing staff and respiratory therapy with the increasing need for prone positioning of patients who were mechanically ventilated s. Rehabilitation therapists possess expertise in mobilizing patients with invasive lines, knowledge of positioning for joint and integumentary protection, and understanding of hemodynamic and ventilatory response to position changes. Multiple factors led to the success of the rehabilitation-based prone team including rapid team development and training, multidisciplinary communication, continuous process assessment and adaptability. The process described met the

needs of the hospital in caring for patients with COVID-19–related ARDS and may serve as a model for future processes.

Positioning patients in prone was not typically performed by rehabilitation therapists at our institution. The knowledge base and experience of rehabilitation therapists was well suited for creating a prone team. Rehabilitation therapists are experts in assessing and assisting patient mobility. With this expertise in the intensive care setting comes an ability to plan movement with invasive lines and safety awareness for both the patient and the clinician. The prone team was able to perform and lead other disciplines in performing the physical position changes. The prone team also managed multiple challenges to ideal positioning related to medical status, body habitus and limited joint range of motion. Problem solving with different techniques and positioning devices allowed for optimal positioning for skin integrity and medical status (Tab. 2).

Creating a new service in uncertain conditions required constant process re-assessment and adjustments. Multiple factors contributed to ongoing development and progression of the prone team. Immediate identification of members for the prone team service and training by rehabilitation leadership expedited implementation of the prone team. Communication between members of the multidisciplinary team was a key factor to the success. Feedback from early experience indicated that identification and confirmation of roles prior to positioning changes was integral to success. With increasing experience, the responsibilities of the prone team evolved. The prone team led the prone positioning process including advising nursing and respiratory therapy on their respective roles and coordinating actions among the multidisciplinary team in the patients' rooms. The prone team also participated in a higher

frequency of head and arm repositioning of patients in the prone position after the support prone team was created. Collaboration with wound care nursing specialists facilitated acquisition of appropriate positioning devices and provided recommendations on positioning and supplies for integumentary protection. Wound care nursing specialists were also consulted for complex needs and participated in a weekly meeting. The prone team provided the supplies needed for each position change which improved efficiency and reduced variability of practice.

There are several limitations to this paper. The results reported is a preliminary description of data collected for tracking the process of the prone team service. No specific identifiers of any events were recorded and retrospective collection of missing or incomplete data is not possible. The volume of requests was likely highly dependent on the number of patients admitted with COVID-19–related ARDS and likely reflects factors such as size of institution, patient acuity and regional cases of COVID-19. It would have been beneficial to prospectively collect data regarding patient outcomes and adverse events. Cause and effect cannot be concluded from the description of the development and progression of the prone team. Comparison of the described rehabilitation-based prone team service to other processes was not examined.

The scope of this paper is to describe the development, operation and progression of a rehabilitation therapist prone team in assisting the multidisciplinary team with the physical positioning of patients with COVID-19–related ARDS into prone. The description may serve as a guide for future development of similar services with an effective, efficient approach. Further research is needed to examine the effect of prone positioning for patients with COVID-19–

related ARDS including patient tolerance, adverse events, comparison of alternative prone team staffing, and long-term outcomes.

[H1] Conclusion

As the COVID-19 pandemic progressed throughout the state of Massachusetts, hospital systems were confronted with providing care for a surge of critically ill patients. The rehabilitation department at Brigham and Women's Hospital created a prone team to assist with positioning patients who were mechanically ventilated into prone, an intervention for COVID-19–related ARDS. There were multiple factors that led to the successful establishment of a rehabilitation-based prone team including baseline knowledge, training, multidisciplinary collaboration and continuous process assessment and adaptability. Over weeks of providing a rehabilitation-based prone team, the verbal feedback from various medical staff has been overwhelmingly positive. The description of our institution's response to prone positioning as an intervention for COVID-19–related ARDS may serve to inform future management of similar challenges.

Author Contributions and Acknowledgments

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Disclosure and Presentations

The authors completed the ICMJE Form for Disclosure of Potential Conflicts of Interest and reported no conflicts of interest.

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Figure Captions

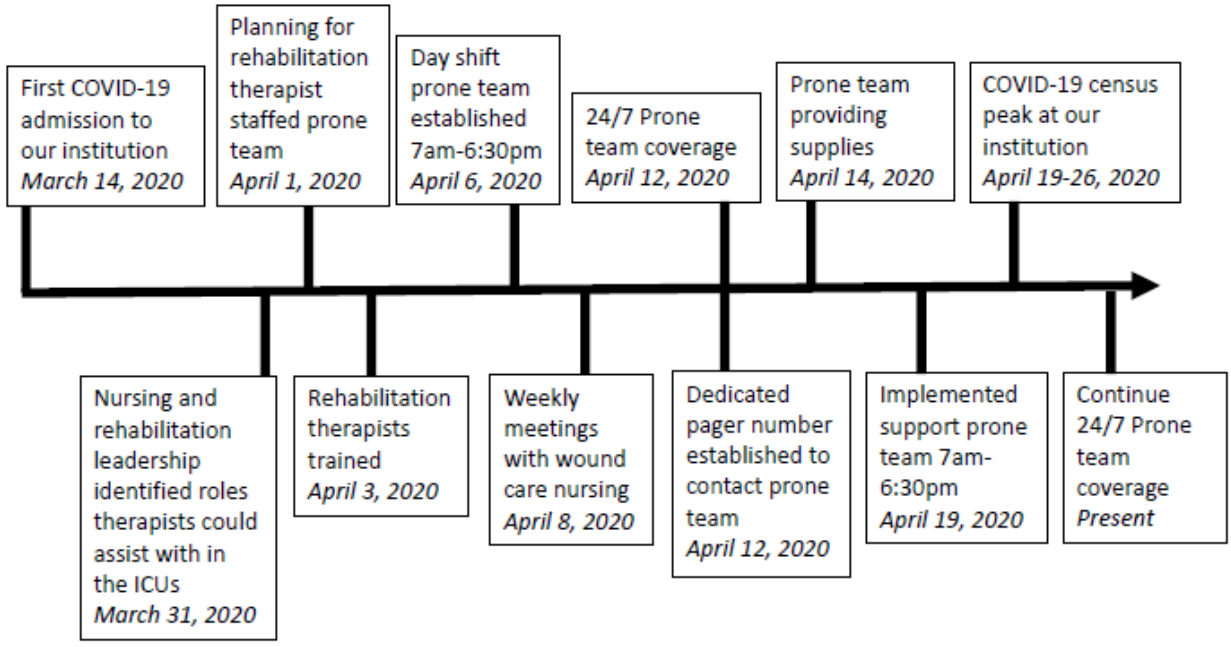


Figure 1. Prone team process timeline.

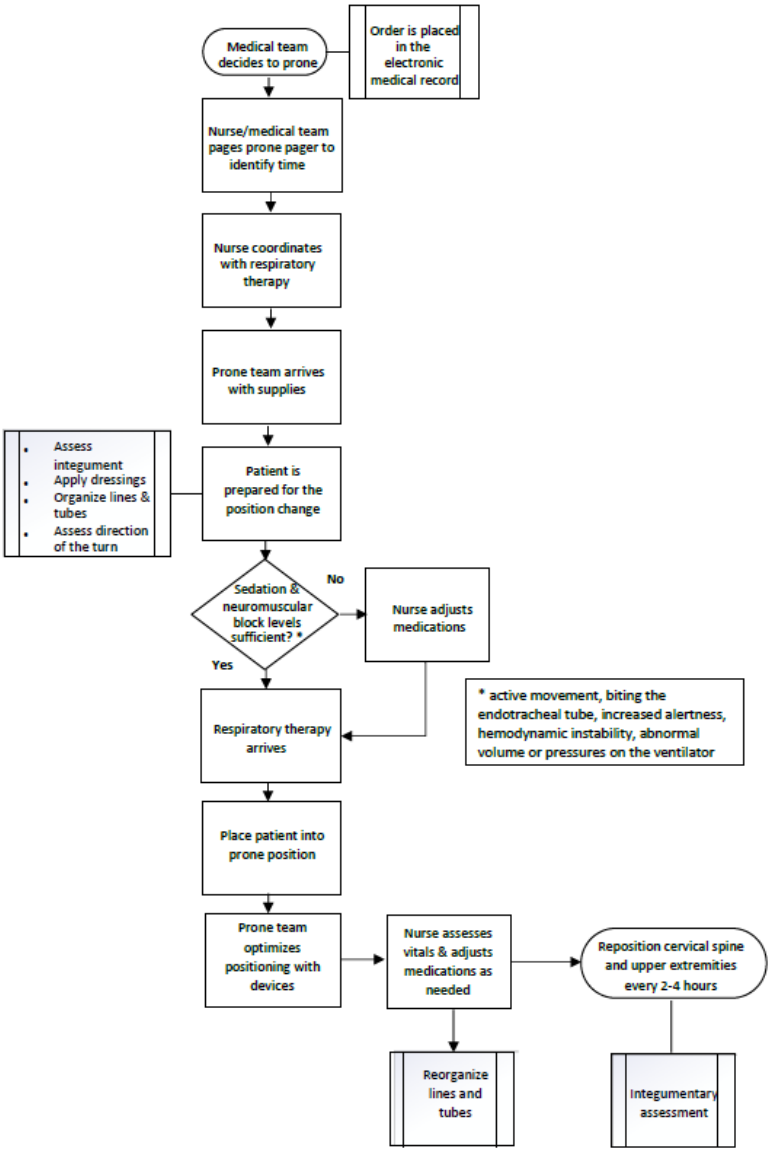
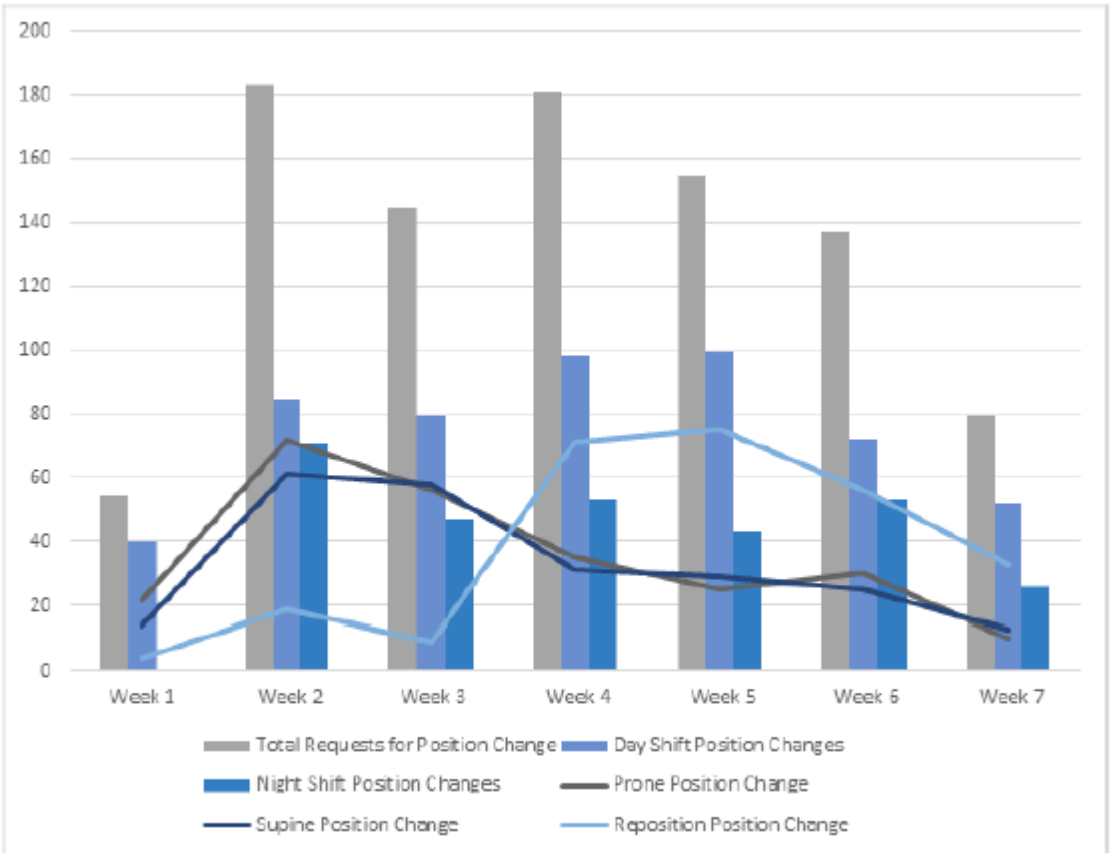


Figure 2. Prone positioning process map.



*Graphic depiction of all completed data, requests with missing data omitted.

Figure 3. Prone team position change requests and volume.

Table 1. Criteria for Prone Therapy[a,b]

Criteria for Prone Therapy
Criteria for consideration of prone ventilation:
Moderate to severe ARDS resulting in hypoxemic respiratory failure with PaO_2/FiO_2 ratio <150 mmHg, PEEP ≥ 5cm H_2O, $FiO_2 \geq 0.6$[9]
Low tidal volume ventilation with tidal volume ≤ 6 cc/kg of predicted body weight
Best PEEP titration previously performed
Indications for return to the supine position:
Duration of the prone therapy ordered has elapsed • Suggested duration in prone is ≥ 16 continuous hours per 24 hours, supine ≥ 4 hours per 24 hours[9]   ○ Physicians adjusted this duration based on PaO_2/FiO_2 ratio
Complications occurring during prone session: • Airway complication or compromise: unscheduled extubation, ETT obstruction, significant hemoptysis, worsening hypoxemia (SpO_2 < 85% or PaO_2 <55 mmHg for more than 5 minutes) • Cardiovascular complications: cardiac arrest, hypotension (systolic blood pressure < 60 mmHg for more than 5 minutes), bradycardia (HR <30 beats/min for more than 1 minute), unstable tachyarrhythmia • Any other life-threatening reason at the discretion of the medical team
Indications to terminate prone therapy:
Improvement in oxygenation with $PaO_2/FiO_2 \geq 150$ mmHg with PEEP ≤ 10cm H_2O and $FiO_2 \leq 0.6$ to meet $SpO_2 \geq 92\%$ or $PaO_2 \geq 65$) which persisted 4 hours after the end of the prior prone session
PaO_2/FiO_2 ratio deterioration by more than 20% relative to supine after 2 consecutive prone sessions

[a]ARDS = Acute respiratory distress syndrome; ETT = Endotracheal tube; FiO_2 = Fraction of inspired oxygen; PaO_2 = Partial pressure of oxygen; PEEP = Positive end expiratory pressure; SpO_2 = Oxygen saturation.

[b]Taken from Brigham and Women's Pulmonary Division, "MICU-Use of Prone Mechanical Ventilation" Guideline, April 4, 2020, unpublished data.

Table 2. Prone Team Roles

Discipline	Role	Decision Making	Challenges		Supplies/Devices	Solution
Prone Team (Physical Therapy, Occupational Therapy)	Organize lines	Work with RN to ensure optimal positioning of lines	Multiple lines from multiple locations		N/A	Per RN
	Assess and prepare integument	Per training with Wound Care Nursing specialists	Limited mobility can increase pressure at bony prominences		Hydrocolloid dressings	Pad bony prominences or at -risk areas
					Absorbent foam	
					Moisture barrier	Protect from oral and nasal secretions
	Lead performance of physical position change	Perform safe transition	Body habitus, medical stability		Bed linens	Flat sheet to assist with rolling and positioning
						Absorbent bed pad to control excessive moisture
	Positioning	Achieve optimal position	Body habitus	Large abdominal girth	Gel rolls/Waffle cushions	Promote thoracic extension and relieve abdominal pressure
				Large breast tissue	Gel rolls/Waffle cushions	Promote thoracic extension and relieve abdominal pressure
				Pregnancy	Gel rolls/Waffle cushions, additional positioners at pelvis and/or anterior hips	Promote thoracic extension and relieve abdominal pressure
			Spinal abnormalities	Thoracic kyphosis	Larger positioners at the upper chest	Promote thoracic extension and relieve abdominal pressure
			Restricted ROM	Cervical	Slotted head positioner	Assists with face down positioning
				Glenohumeral	Pillows and towels	Alternative upper extremity positions
			Head position	Face down positioning	Fluidized pillow	Head support and allow for pressure relief at ET tube and around face
	Monitor and assess vitals	Work with RN & RT to confirm vitals	Effect of positioning		Telemetry, pulse oximetry, invasive blood pressure line	Per MD, RN or RT

Table 3. Prone Team Activity

Activity	n	Percentage
Prone Team Requests		
Total Requests	934	
Week 1 (4/5-4/11)	54	
Week 2 (4/12-4/18)	183	
Week 3 (4/19-4/25)	145	
Week 4 (4/26-5/2)	181	
Week 5 (5/3-5/8)	155	
Week 6 (5/10-5/16)	137	
Week 7 (5/17-5/23)	79	
Time Spent During Position Change		
Total times entered	821	
Missing data	113	
Mean (SD) Minutes	20.2 (9.15)	
Range Minutes	5 - 80	
Number of Prone Team Members Involved with Position Change		
Total times entered	838	
Missing data	96	
Frequencies		
1 prone team member	13	1.6
2 prone team members	221	26.4
3 prone team members	593	70.8
4 prone team members	11	1.3
Type Position Change		
Total times entered	932	
Missing data	2	
Cancelled	88	9.4
Prone	253	27
Prone/Supine	4	0.4
Reposition	280	30
Supine	235	25
Turn	72	7.7
Shift Request Volume		
Day shift	601	64
Night shift	333	36